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ALUMINIUM PRODUCTION AND USE IN DEVELOPING COUNTRIES WITH SPECIAL EMPHASIS ON THE MANUFACTURE OF ALUMINIUM SEMIS AND FINISHED PRODUCTS *

Conducted by a working team of
ALUTERV-FKI, Budapest (Hungary)
under the leadership of Istvan Varga

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EXPLANATORY NOTES

A full stop /./ is used to indicate decimals.

A comma /,/ is used to distinguish thousands and millions.

A stroke-line "/" is used to indicate "per", for example t/a = tonnes per annum.

A stroke-line between dates /for example 1979/80/ indicates an academic, crop or fiscal year.

A dash between dates /for example, 1970-1979/ indicates the full period, including the beginning and end years.

References to dollars /$/ are to United States dollars unless otherwise stated.

The word billion means 1,000 million.

The following notes apply to tables:
Three dots /.../ indicate that data are not available or are not separately reported.

A dash /-/ indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

The investment costs and suggested capacities in this study are estimated values.

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I. AIM OF THE STUDY, GENERAL OUTLINES

The study aims to contribute to the development of the aluminium industry in developing countries.

The development of finished goods production has been primarily highlighted and the necessity of development of semis production has been outlined in this study, on the presumption that the aluminium base material would be available in the country either by local production or by imports.

Besides general development concepts considering production of semis and finished goods, the aim of this study is to enable the Governments and their official organizations dealing with the development of the aluminium industry to:

- decrease the period preceding investment activity,
- reduce expenditures of this kind,
- specify more precisely the inquiry for offers concerning the establishment of particular plants,
- evaluate offers, and
- make prompt decisions.

The study gives a concise analysis of the world's aluminium production and consumption and forecasts them till the year 2000. It deals with the possibilities of establishing the aluminium industry in general. (The particular questions to be answered before preparing a pre-feasibility study in a specific, given country are found in Appendix I.)

In addition it shows possible modes of increasing consumption of aluminium, modes or proper and economic application of aluminium, factors influencing the end-users' decisions, and methods of influencing customers' decisions.

In the study, aluminium-semis requirement of finished good manufacturing is grouped as follows: rolled products, extruded-drawn products, wires, cast and forged products.

This study is a short term (5 years) development program (customarily named as middle-term one) and includes the technology of the proposed semi- and finished product-manufacturing plants, the list of equipment together with their minimum and maximum capacities. It summarizes the feasible, profitable capacities, the dimensions of the plants, the plants' specific requirements concerning raw materials, power, water, manpower as well as the estimated capital and operating costs, etc. The study provides the costs and sources of technology and know-how.

Measures are also recommended to promote product-developing activity including technical advice and research to boost economic aluminium consumption. Special emphasis is laid on the organization of the development that should provide technical advice on proper application, training, marketing and standardization. The recommendations are summarized in Chapter IX.

II. ANALYSIS OF THE WORLD'S ALUMINIUM PRODUCTION AND CONSUMPTION

A. Possibility of assuring raw material

The estimated bauxite reserve of the world which can be economically exploited by technologies of today is about 25-36 billion tonnes involving not only prospected deposits but include supposed ones as well as reserves unknown till now.

On the level of about 88 million tpy bauxite exploitation, the reserves should provide raw material for aluminium production for 300-400 years. Seventy-five per cent of bauxite reserves can be found in developing countries:

In Africa	36 %
In Latin America	28 %
In Asia	11 %

It may be supposed that the quickest growth of aluminium industry would be in developing countries in the next decades.

It is a paradox fact that the biggest aluminium producers and consumers (such as North-America, Western-Europe and Japan) do not have bauxite reserves to a large extent. The reserves are situated in the territories of developing countries and this fact makes it necessary - for decreasing expenses of transportation - to settle alumina plants near bauxite sources. As the cheaper sources of energy can usually also be found in developing countries, the need for reduction of energy and transportation expenses strengthen the tendency of smeltery shifting as well.

At the same time, it should be noted that the very long period which is needed for infrastructural development in a wider reason contrasts with the tendency of shifting the production capacity to developing countries.

By way of introduction, we draw attention to the fact that basically the products of the first three phases of the aluminium industry (i.e. bauxite, alumina and aluminium metal) are involved in large volumes in international transport and trade. The direction of these transports is from developing regions towards developed (or more developed) industrial regions, due to the lower level of existing infrastructure, industrial background and consuming culture as well as to the more expensive investments at site in developing regions.

Directions of movements of semis and finished products of the last two phases of the aluminium industry are reversed, but in volume they are significantly less (by several scales). Accordingly, developing countries should assign particular importance to the development of the last phases of the aluminium industry, especially the finished goods production.

Bauxite and alumina balance of continents is shown in Table 1. On the basis of production and consumption data of primary aluminium in the world, a balance can be presented as shown in Table 2.

Considering the whole world, it is to be expected that bauxite excess will occur from the mid-1980s and it is supposed for alumina capacity as well, up to the end of this decade. Some bauxite mines and alumina plants may account for a low level of utilization of capacity till 1985.

The abundant bauxite capacities and the simple method of storage make it possible to control the quantity of bauxite production following the need of alumina production. The alumina capacities cover also the need of smelters abundantly, at the same time, the storage poses several problems which cannot be solved easily.

Table 1.

Bauxite and alumina balance of continents

1980. (1000 t)

Continent	Bauxite capacity	Alumina capacity	Aluminium capacity	Bauxite±	Alumina±
North-America	2000	8507	6080	-17566	-3349
Latin-America	32705	5119	919	+20931	+3327
Africa	14920	691	470	+13331	-225
Asia	5910	4388	2538	-4182	-561
Europe	15440	8325	4451	-3707	-354
Australia	29600	7338	520	+12723	+6324
USSR	7450	4090	2000	-1957	+190
	108025	38458	16978	+19573	+5352
1990.					
North-America	2000	9822	8065	-20590	-5905
Latin-America	55470	13000	3180	+25570	+6789
Africa	47320	7700	1645	+29610	+4493
Asia	18960	7848	4780	+910	-1473
Europe	16700	12505	5407	-12061	+1962
Australia	50040	11636	2556	+23277	+6652
USSR	11020	7740	2805	-6782	+2270
	201510	70251	28438	+39934	+14788

Note: For 1 t alumina 2,3 t bauxite, for 1 t aluminium 1,95 t alumina is considered

Source: Australian Mineral Economics Pty. Ltd. Aluminium 1982. febr.

Table 2.

Production (P) and consumption (C) of primary aluminium in the world till 1995 (in 1000 t) - based on Predicast Nov. 1981.

		1980	1985	1990	1995
	P	5722	6750	8000	9450
	C	5028	6780	8530	10300
North-America		694	-30	-530	-850
	P	837	1530	2630	3915
	C	563	900	1385	1915
Latin-America		274	630	1245	2000
	P	2227	2795	3450	4190
	C	3083	3785	4635	5620
EEC		-856	-990	-1185	-1430
	P	1366	-1570	1815	2100
	C	724	970	1270	1630
West-Europe (others)		642	600	545	470
	P	3137	3905	4635	5430
	C	2940	3635	4455	5380
East-Europe		197	270	180	50
	P	587	870	1200	1430
	C	196	310	450	610
Africa and Middle East		391	560	750	820
	P	2194	3350	4660	6150
	C	3126	4125	5440	6960
Asia and Oceania		-926	-775	-780	-750
	P	16070	20770	26390	32665
	C	15654	20505	26165	32415
World		416	265	225	250

In the first two phases of aluminium industry, the quantity of production is necessarily controlled by the quantity of primary aluminium production. This holds also for the future to such an extent that in the world trade of bauxite and smelter grade alumina, the development of a seller's market would not be supposed even for a short period.

Within the production phases of the aluminium industry, the bauxite and alumina supply is safe in the world in the foreseeable future. Those regions which have no bauxite and alumina production are also able to cover their needs continuously but from a great distance.

From time to time, shortages appear in the smelting phase in the world.

B. Trends of production and consumption of aluminium metal

Development of usage and production of aluminium on a world scale can be assessed by the comparison of the successive periods of the 20th century. Analysis of the periods differing from one another in nature helps to value the present situation in its reality.

Table 3.

TREND OF THE WORLD CONSUMPTION OF PRIMARY ALUMINIUM IN QUANTITY, PER ANNUM
(more detailed in Fig. 1.)

Years	Consumption, '000 tons
1900	5.7
1910	44.4
1920	131.0
1930	209.0
1940	820.0
1950	1,585.0
1960	4,166.3
1970	10,028.0
1975	11,676.0
1979	15,923.3
1980	16,500.0
1981	15,837.0

In the history of aluminium production the following periods can be differentiated: (see Fig. 1.)

- The first increasing period lasted till 1918, to the end of the World War I.

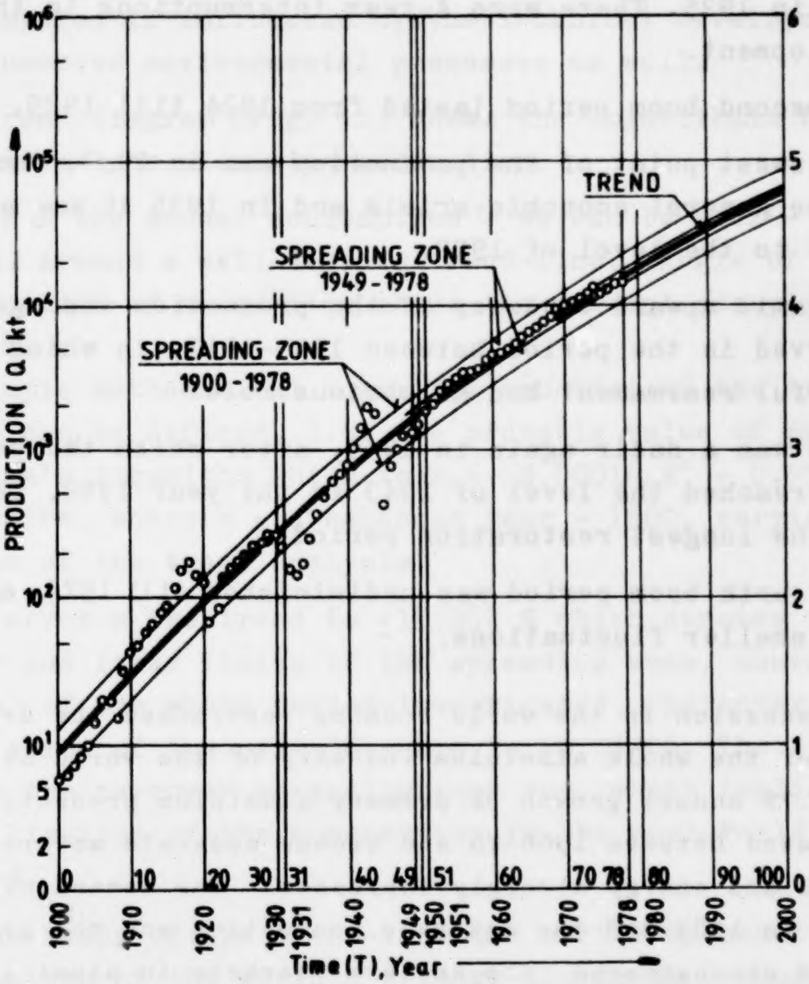

Fig. 1. Trend of the World's primary aluminium production (logarithmic layout)

- The decline following World War I reached its lowest level in 1921. The level of 1918 was reached again only in 1925. There were 4-year interruptions in the development.
- The second boom period lasted from 1924 till 1929.
- The lowest point of the production was in 1933, because of the general economic crisis and in 1935 it was again close to the level of 1929.
- A dynamic upward tendency of the production was again observed in the period between 1935-1943, in which the powerful rearmament had an obvious role.
- There was a nadir again in 1945, after which the production reached the level of 1943 in the year 1952. This was the longest restoration period.
- The fourth boom period was undiminished till 1974, apart from smaller fluctuations.

The recession in the world economy restrained the development of the whole aluminium industry of the world as well. The 7.7% annual growth of primary aluminium production decreased between 1966-76 and became moderate as price of oil and energy strongly increased. The demand climbed up again in 1983 and the moderate production and the growing demand strengthened the sellers' markets in aluminium supply which will probably lead to an increase of aluminium prices till 1985.

The price, capacity and demand should become balanced from 1985 onwards.

To determine the present and future feasibilities of the various products, more and more analyses are being done. The progressive, the linear and the degressive stages of development are generally differentiated. For raw materials, such as aluminium, an analysis cannot be carried out because the life-span of its application may last as long as many decades, perhaps even centuries, and the consumption is influenced by the technical development and numerous environmental processes as well.

The trend diagram (Fig. 1.) shows the logarithmic layout of the world's aluminium production.

Points of the annual consumption - as can be seen - are spread around a well-defined trend-line. (Angle of inclination of trend line shows the current annual growth.)

By simple mathematical means the equation of the trend--line can be defined, i.e. the probable value of production's logarithm which is $y = -0,00016\ x^2 + 0,05397\ x + 0,95584$, where x = a calendar year - 1900, varying time factor of the trend analysis.

Mean error of the trend is ±15,862 % which denotes the upper and lower limits of the spreading zona, characteristic of the whole period investigated. Characteristic mean error of the past 30 years is ±0,04206. The diagram shows the narrower spreading zone too, which implies the stabilization of the consumption in the post-World War II period.

On the basis of the trend-line the strict mathematical estimation of the world's primary aluminium production is shown on Table 4.

Table 4.

WORLD'S FORESEEN PRODUCTION OF PRIMARY ALUMINIUM
(according to the strict mathematical trend)

Year	Production in 1,000 mt
1985	24,320
1990	32,880
2000	56,620

During the years the trend of the world's aluminium production has exceeded the values extrapolated from the trends of previous periods. This fact shows even in itself the progression of the development, regardless of the seasonal changes.

In spite of this, estimates of global growth rates of the relative values of structural materials, consequently of their potentials for substitution by each other, had become doubtful. Simultaneously it also became clear that the economic future of developing countries, which group often used to be regarded as a monolithic entity, will probably differ to a great extent. The group of "well-off" developing countries has emerged (an arbitrarily introduced term). It consists mainly of Latin American countries and a few other "front-runners" of development. Beside national resources, these countries also avail of manpower capable of organized work, an essential condition of development. Opposite to this, in the extremely low-income countries of Asia, Africa and other geographical regions, previously prognosticized agricultural and industrial development targets could not be met even in case natural resources were more or less available. The non-satisfactory level of social development, also of the aptitude for work of the local population serve here as the main obstacles.

Experts, when elaborating recent forecasts use also to credit duly the mentioned limiting factors. According to more recent forecasts the elasticity quotient of GNP and aluminium consumption growth has a general tendency to decrease and is getting increasingly differentiated by economic regions. It appears that in case of industrially developed countries this quotient, which used to be 1.2--1.3, will decrease in the next decades to 0.9-1.0. At the same time values to be expected will be: 1.3-1.4 for Latin America, 1.4-1.5 in case of the "least developed" countries, and 1.0 for the centrally planned economies.

Thus, the most recent forecasts - presuming the prevailing technological situations - estimate 33 million tons of world primary aluminium consumption in 2000.

The abatement of aluminium consumption growth rates is mainly due to the following factors:

- growth-increments of GNP in developed countries mainly originate from industrial sectors which are not intensive consumers of aluminium (e.g. electronics, telecommunication). Developing countries represent an exception, because in their case intensive electrification programmes, also the structure of industry reminiscent to the previous situation in developed countries, as it existed between 1960 and 1970, resulted in a higher specific demand of the light metal,
- capital costs for investments to create new primary aluminium metal production capacities are steadily increasing (due inter alia to costs of infrastructure, supply of energy, the role of increasing production unit sizes strict standards of pollution control),

- the emergence of new areas for aluminium application displays a diminishing trend except for air transport and road vehicles,
- the proportion of prices between aluminium and other structural materials (especially alloyed steels and some plastics) has shifted to the detriment of aluminium. (E.g. whilst world market aluminium price in 1979 was 2.32-fold compared to the 1972 level, alloyed steel prices rose simultaneously only to their 1.68-fold.)

The structure and sectoral breakdown of aluminium consumption by regions, respectively individual countries, depends not only on the general economic situation but also on related structures of local industries. The comparative analysis of aluminium end-uses by regions appears as an attractive topic, also tempting toward preparation of elaborate forecasts. However, in reality the partial lack of initial data, also the complicated and changing patterns of influencing factors allow to conclude only some fundamental lines of tendencies.

Among such general conclusions, the following should be mentioned:

- the four main economic regions are displaying distinct types of end-use patterns: in developed market economies the brunt of consumption arises in transport, construction and packaging; in the group of "well-off" developing countries electrical industries have a great role, domestic utensils show a decrease, production of transport goods grows, whilst packaging - depending on food industries - and construction - depending on factors of local climate - may also have a potential for growth; the bulk of aluminium consumption in the least developed countries prevails presently in the household goods production and electrical industries sectors; in the centrally planned economies, independently from their respective levels of industrial development, under conditions of an under-saturated market, electrical engineering is prevailing as the main civil consumer,

- as a result of world-wide industrial development it appears as probable that end-use patterns of all main economic regions will, however, slowly but gradually approach the present patterns of developed market economies,
- world demand of highly processed, special aluminium semis is increasing and as a result the borderline between aluminium semis and finished goods becomes increasingly blurred; this phenomenon manifests itself in case of some developed countries with small population by a sharp increase of the exported share of semis which may attain or even surpass 50 %; assembly plants and workshops for the use of these goods are mushrooming in the developing countries,
- the emergence in the coming 20 years of new products for civil uses, able to absorb significant quantities of aluminium cannot be expected even in the developed countries,
- some previous observations still stay valid, accordingly: in the developed countries requirements of energy saving will expectedly call for an increase of aluminium consumption in the field of transport vehicles, in electrical industries, in the production of heat exchangers and vessels, in the mass production of some machine building components, also in case of goods serving vacation and sporting entertainmentes, however, growth of aluminium consumption for building and packaging will abate; in the initial period of development, as it can be observed in case of medium-developed and developing countries the use of aluminium in electrical industries, in some cases also the widely spread use of packaging goods made from aluminium (e.g. to serve new plants for fish-, milk-proc-

essing, also the production of other canned products), the establishment of household-goods making industries is also having a decisive role; the other aluminium consuming sectors use to follow suit gradually, depending on specifics in the country's economy; agriculture requires up to date cold storage plants, installations for irrigation, desalination of sea water, pre-fabricated building structures; components for vehicle- and machine-building appear first in assembly plants, later on they are made in separate production facilities, like high quality mould-casting foundries,

- it is reasonable to start, parallel to the development of aluminium fabrication and processing also the collecting and remelting of aluminium scrap in an efficient way; the quantity of scrap uses to be 21-26 % of aluminium metal turnover.

As a final result the probable maximum consumption is shown in Table 5.

It is to be noted that the 1985 figures of this Table seem to be rather optimistic in the present situation, but later years' estimates might still be valid. More conservative estimates predict however a lower consumption level say about 30-32 million tons only in 200, but it is hard to say which of these assumptions will prevail.

The consumption of aluminium depends on a series of influencing factors and nobody can foresee exactly how these will work out. Anyhow, a considerable increase of alumina consumption can be expected for the year 2000.

Table 5.

Joint consumption of primary and secondary aluminium

in million tons

	1980	1985	1990	2000
Europe (without countries with centrally planned economy)	5,6	6,5	7,5	9,9
USA	6,2	7,1	8,1	10,7
Japan	2,1	2,5	2,9	3,8
Other developed countries	1,0	1,2	1,5	1,8
1./ Developed countries total	14,9	17,3	20,0	26,2
Latin America with Mexico	0,7[4./]	1,0	1,3	2,1
Middle-East oil countries	0,3	0,4	0,5	0,8
2./ Developing countries total	1,0	1,4	1,8	2,9
3./ Asia,[1./] Africa[2./] and other countries with low income	0,6	0,8	1,0	1,7
European countries with centrally planned economy	3,1	3,6	4,2	5,5
China + other countries with centrally planned economy[3./]	0,6	0,8	1,1	1,8
4./ Countries with centrally planned economy total	3,7	4,4	5,3	7,3
All together total	20,2	23,9	28,1	38,1

Note: 1./ Without Japan, China and oil-producing countries 2./ Without, Middle-East oil producing countries and South-Africa 3./ Estimate 4./ Aluminium /Düsseldorf/ 01.23.1982.

C. Production and consumption of semis

There are no reliable data about the global productive capacities of aluminium semis (the most important plants of semis in Europe and their capacities are shown in Appendix 2.)

The use of semis is about 80 % of total aluminium consumption and share of certain types of semis in total usage is shown in Table 6.

Table 6.

DISTRIBUTION OF THE CONSUMPTION BY TYPE OF SEMI-PRODUCTS

Semi products	%
sheet and strip	43.2
circle and slug	2.5
foil	7.1
welded tube	1.2
rolled products total	54.0
extruded profile	2.9
shape	15.4
tube	1.4
drawn tube	0.7
extruded products total	20.4
wire and cable	7.7
forgings	1.2
pigment	1.2
mould castings	15.5
	100.0

Requirements of finished products' manufacturers created the horizontal split-up of the vertical structure of semis' production as it is nowadays. Variety of semi-products - available in different countries - has a certain reaction on the finished products' manufacturing. The prime factors, however, are the requirements, changing only slightly during a short period.

Application according to consuming branches varies considerably in the different countries in the same period.

Table 7.

Consumption according to branches, %

	minimum	maximum	rank N°
Vehicle production	5	30	3
Machine industry	1	15	5
Electrical engineering	5	50	1
Building and construction	6	48	2
Chemical ind., agriculture, food processing	1	5	8
Packaging	4	29	4
Household utensils	3	15	6
Mass products	1	12	7
Miscellaneous	4	6	9

Consumption of industrial branches in various countries depends first of all on the structure developed, consuming practice, foreign trade connections and income relations.

There are great differences in the structure of consumption in various countries even if they are on nearly the same level of development. The difference among the countries for different technical level is far greater not only in the distribution of applications according to the branches, but also in the consuming capacities and in the per capita consumptions.

There is a very close relationship between the aluminium per capita consumption and the GDP (Gross Domestic Products). This is shown in Table 8.

Table 8.

GDP PER CAPITA IN RELATION TO ALUMINIUM CONSUMPTION
(in the last decade)

GDP	Aluminium consumption	
$ per capita	kgs per capita	kgs/1,000 $ GDP
300	0.50	1.66
500	1.00	2.00
1,000	2.60	2.60
2,000	6.75	3.38
4,000	17.50	4.38

Aluminium consumption was growing regularly to a greater extent than GDP. 1 % growth in GDP implies in average 1.43 % consumption of aluminium.

D. Foreign trade of products of the aluminium industry

In order to set up an aluminium industry in its complete form, there are some necessary conditions to be satisfied such as availability of bauxite, low cost electrical power and considerable capital resources that are, however, scarcely disposable simultaneously in the same country. Bauxite mines coincide geographically not always with alumina factories, and there are countries producing large quantities of alumina without having any bauxite at all, whereas other extracting bauxite countries exist which have no alumina production.

The largest part of primary aluminium is made from alumina which has bauxite origin. Bauxite production is concentrated in tropical areas and since there isn't enough electric energy for manufacturing processes in these territories great quantities of bauxite are moved in international trade in spite of increasing transport costs.

About 30-40 % of the exploited bauxite takes part in this turnover. The greatest importing countries are: USA, FRG, USSR and Japan. The free market of bauxite is relatively small. The majority of alumina plants are set-up to a special quality of a mine or a source and they aren't flexible to process different bauxites with different types and quantities of Al_2O_3 from time to time. To assure a low (optimal) level of specific consumption in alumina plants bauxite process has to be uniform in every respect.

The price of bauxite is determined to a great extent by its SiO_2 content (beside its Al_2O_3 content). However it is rather difficult to get a conceivable picture about the price of bauxite because in most cases the deals take place between companies of the same group. Price of bauxite can't be given by a formula, buyer and seller generally agree on a standard quality and increase of Al_2O_3 as well as decrease of SiO_2 contents increase its price. Price of bauxite - similarly to other ores - became three times higher between 1970 and 1980, and it can be said that the CIF price of bauxite (CIF USA for one ton of dry bauxite with 50 % Al_2O_3 and 8 % SiO_2 content) amounts to 2 % to that of a ton of crude aluminium. Price changes will be determined by that of aluminium and energy till 1990 and 1995, respectively.

The IBA established in the early 70s was not able to restrict the market as OPEC did. Its aim was to assemble bauxite exporting countries. After its establishment research boomed to find non-bauxite type raw materials for alumina production. Up to now only alunite has reached a given level of development. Developing program of alumina production on the basis of non-bauxites became slower due to the discovery of new, enormous bauxite reserves, lack of demand and the expensive manufacturing methods of non-bauxite raw materials.

Selling and buying operations of alumina are rarely recorded in international trade. Available data refer to sandy alumina produced by the Bayer process serving for metallurgical use. About 40-50 % of the alumina produced takes part in the international trade, the amount of which will decrease considerably till 1995 due to an increase in transport costs. The greatest alumina exporting areas are Australia, South-West Africa and Latin America. Similar to bauxite prices, that of alumina cannot be determined exactly because transactions of the latter also take place between interlinked companies.

Price of alumina was generally predicted to be 11-14 % of ALCAN metal price for a longer range (Marc Rich, Alcoa of

Australia, Prognos).[1] Expected alumina price for 1990 is 230-400 $/t on Fco parity of SIC nomenclature.

There are countries where the setting up of alumina production and electrolysis does not coincide as well as countries which produce primary aluminium but no alumina.

List price of aluminium varies traditionally once or twice per year. There was a balance between capacity and demand in the 60ies and the early 70ies so the price increased proportionally with production expenses. The high energy prices and taxes on bauxite have raised expenses quickly from 1973 onwards.

In the late 70ies the demand of aluminium rose up rapidly in the world and there was even a shortage so prices increased rapidly. This situation changed suddenly in the first years of the 80ies and consumption went down like prices did. The lowest point occurred in 1982; since then prices increased again and the market situation improved, too. It may be expected that this situation will last for another year or so but the year 1985 will bring a balanced market and a slowing down of price increase.

Both exchange and producers prices in the USA may prove some profit again in 1984. The exchange prices will be somewhat above USA list-prices in the years 1988-90 showing a sellers' market essentially. The improving price gap encourages to increase capacities at the end of the decade, decreasing the possibility of a serious shortage in metal.

The international trade of semis grows year by year. The completing international cooperation, the effort for realizing optimal production series and the setting up of specialized production units promote the increasing international trade of semis. Interchange of semis among countries is motivated by complicated international connections of interests as well. As a result of this most countries perform great export and import transactions at the same time. From the point of view of world trade, it is decisive whether the trade balance of the countries show in favour of their exports or imports and in which direction the tendency of export or import develops.

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[1] Due to the fact that the ALCAN-price does not exist any more, some similar reference basis has to be considered for the metal.

In summary: trade of bauxite and alumina is about 50 %; 25-30 % of the world's primary aluminium ingots get into foreign trade. Only 9-10 % of semis and a far smaller part of finished goods get into the world trade.

Bauxite and alumina cannot be represented on the world market because

- multi-national companies manage trade among their own firms,
- of trade of long-term delivery contracts between firms producing raw materials, and using this raw materials,
- "spot" deals are relatively scarce.

Aluminium is a real world market item to the contrary of bauxite and alumina.

In lower phases of aluminium industry's structure, the prices generally follow the world market prices but they are less changeable. Price of 1 ton bauxite is one tenth of the alumina price for the same quantity, or maximum 2 % of the ingot price, in general.

Price rates of alumina - aluminium fluctuate between one sixth - one ninth, depending on business cycles.

In spite of the disturbing circumstances, aluminium has a well defined real world market price. Ingot sale within the monopolies is still of remarkable importance but in the industrialized countries, there are a lot of aluminium consumers belonging not to the monopolies and, in addition, these are real buyers.

The aluminium market is strongly regulated. Metal, as it can be used for strategic purposes, has an official regulated market price in several countries, setting limits in this way to prices of imported aluminium. Strategic stockpiles controlled by the governments sometimes present an opportunity to affect prices. Significance of the free market is not to be dismissed. Share of potential consumers on one hand and the possibility to affect prices by buying up stockpiles or throwing them on the market on the other, seem to be beneficial to the monopolies, too. Besides the direct extra profit, companies influence their governments by price manipulations in order to lift inconvenient restrictions and to increase official prices; they influence development aims of contractors who have not too much experience in aluminium industry.

There are countries, which use - beyond their domestically produced aluminium - imported ingots too, to satisfy their growing demands. These are - among others - Austria, Belgium, Denmark, Italy, Finland, France, Japan, the FRG and the USA. Their imports show a growing tendency. Their common feature is that they do not have low cost electric power and the labour costs are relatively high. Ingot exporting countries like Canada, Norway, have inexpensive hydroelectric power but labour costs are high. All countries with low power+labour expenses lower than those of Norway and Canada may successfully compete with them on the European market provided that the difference in transport costs do not consume the difference of lower power+labour costs.

In the semi-production, notable expenses arising from the use of energy have to be added to the costs of aluminium ingot. Transport costs are not too high as compared to that of raw material. World market price is not a firm point in this case, because semi-production is being horizontally built up. Prices of traditional semis are 140-200 % higher than those of aluminium ingot. A mass-unit comparison would be of no use, as prices of semis as well as phase costs of manufacturing processes from ingot to semis do not depend directly on the ingot's price, fluctuation of prices as compared to aluminium appears only later in time. It is not a lucky practice to sell the semi products at a price below the real value to the manufacturers of finished goods, just to sponsor their activity. This leads to causeless waste of aluminium which could easily be sold on the world market otherwise.

Exporting semis is advantageous only if the price margin between semis and ingot is greater than the production cost of the process from ingot to semis.

In case of an already existing semi-production plant, the price margin should cover the direct expenses that are quantity proportional.

In the finished goods' production, labour has greater importance than in the metal production and also less processing equipment are used. Quantity and costs of auxiliary materials will rise, though.

Prices of finished goods are more apt to variations than the same of the semis. Simple mass products may cost twice as much, complicated ones 7-times as much as the ingots. Their prices are more affected by technical level, advantages as well as savings resulting in their use, etc. than by their production costs.

As compared to other aluminium products, monopolies of the aluminium industry have not too much word in the selling of finished goods. They insist on trying to extend their influence directly or indirectly on finished goods production, too, but it is not remarkable for the time being.

The market of finished goods appears to be subject to changes. Useful life of the products is short, it is therefore very difficult to make an exact and well founded, specified proposal for longer periods regarding production, realization and particularly export. Trends, tendencies can be prognosed on the other hand.

Smaller workshops with less automatized equipment but with a possibility of changing product mix in a relatively short period of 3-4 years surely operate more safely but with less profit.

This is especially true for enterprises or countries where there is no tradition in end-products manufacture and no traditional market of well-established goods.

Goods producible in greater volumes and with modern technology at lower costs, i.e. those that are worth developing, can be chosen in the course of development.

Long range demands for aluminium end-products and export markets for longer periods cannot be estimated definitely. Starting point may be an estimate without consumption structure.

Average aluminium consumption of developing countries is 0.33 kgs per capita; in geographical breakdown:

Africa	0.14 kgs/capita
Asia	0.25 kgs/capita
Latin America	1.10 kgs/capita.

Production of finished goods in the aluminium industry is taking shape, but the developing process is slow and very likely will not include every sort of products. There is a possibility to specialize by dividing production, by cooperation, and mutual agreements shall evidently consider existing situations. A country which has gathered more skill and experience and already possesses significant capacities of finished goods production, is in a more advantageous position in concluding agreements concerning the co-operation with other countries and division of production.

We assume that these considerations would encourage developing countries to start to develop finished goods production on time.

III. THE POSSIBILITIES OF ESTABLISHING AN ALUMINIUM INDUSTRY

A. Possibility of increasing the aluminium consumption

Industrial-scale production of aluminium has been conducted for about 100 years. During this relatively short period aluminium consumption has greatly and widely increased which - compared to other metals - is unprecedented, on the one hand due to the advantageous properties of aluminium, and on the other due to the fact that until now the price of aluminium has slowly risen compared to that of other metals and structural materials.

Consumption estimate of aluminium in any country can be based upon the following facts:

- the use of its relatively inexpensive electric power resources
- the more advantageous physical properties of aluminium compared to other structural materials - in proper fields of applications
- the economic efficiency of proper application of aluminium
- the expected quantity of available basic aluminium material.

The main conditions of increase in aluminium consumption are as follows:

- availability of aluminium in the required form
- user's demand capable of absorbing the available quantities of semis.

The problem of increasing the aluminium consumption is approached from two aspects: production and consumption.

Demand and consumption is, in general, devided according to international nomenclature:

- vehicle-producing industry
- machine industry
- electrical industry
- agriculture, chemical and food industry
- packaging industry
- household utensils and goods
- iron and steel industry
- mass production
- miscellaneous fields.

Demand for semis is grouped according to the above nomenclature, or globally as per the following breakdown:

- rolled semis
- extruded-drawn semis
- castings, forgings.

To increase the aluminium consumption considerably, the availability of large quantities of aluminium semis in proper assortment alone, is not sufficient, but increasing the consumption should be advantageous for the end users, too. (In general, aluminium consumption of a country is not taken as the consumption of end users but that of the aluminium-consuming industries.)

Neither the development concepts for increasing the production, nor the estimations for increased consumption answer generally the following problems:

- criteria of increasing the aluminium consumption in customary fields of application

- new fields of effective aluminium application.

B. The proper and economical use and application of aluminium

1. Factors determining the end users' decision

During manufacturing of a product, the manufacturer has to choose among a range of structural materials that can be applied for the same purpose. Choice is influenced by both technical and economic considerations. To apply the use of aluminium, the following aspects are to be considered:

- advantageous properties of aluminium in respect of the final utilization
- user's habits, application techniques
- price of aluminium compared to that of other structural materials
- additional economic advantages in application arising from the properties of aluminium
- availability of the different materials
- state interference, preferences.

Consequently, the end users' aspects have also to be considered.

The advantegous properties of aluminium are as follows:

It is light, its specific weight is one-third of that of the steel. Strength of its particular alloys reaches to that of the steel. In addition, they can be formed into various shapes. Aluminium is corrosion-resistant, weather-proof without surface treatment, and a good electrical and heat conductor. Aluminium structures require little maintenance, and are fire-proof.

Aluminium has also disadvantageous properties compared to steel which are as follows:

- lower modulus of elasticity
- the welding needs special apparatus
- higher sensibility for fatigue.

The price of aluminium affects the user's decision in connection with the price sequence of the structural materials which can replace each other.

Comparison of prices as per weight and volume does not supply adequate information. The figures do neither indicate all the economic advantages of aluminium, e.g. painting is not required as in case of steel, higher life-span compared to that of wood and plastics; nor its disadvantages, e.g. lower conductivity and lower capacity of heat transmission compared to copper.

Taking the present commodity prices into account, an aluminium structure will, in many cases, probably cost more than a steel structure. In some cases the price difference between the load-bearing aluminium structure and the steel structure should be compensated by the more advantageous properties of aluminium compared to that of steel. In other cases, simple and cheap workability, low maintenance requirement, elimination of surface treatment, high life-span, high scrap price, low transport and operating costs owing to weight decrease, etc. can compensate for the price differences.

To forecast user's decisions it is imperative to take the additional secondary economic advantages into account. In a country where there are no ingrained habits and extensive experiences as in most developing countries, users' habits do not play an important role. Application technique plays, however, an important role the creation of which may be essential in the first phase of the establishment of an aluminium industry (this study will return twice to this fact).

2. Method of forecasting the user's decisions

Considering the primary costs only, aluminium structures are in most cases more expensive than steel or wood structures used for the same purpose but they are cheaper than structures of plastics and non-ferrous metals. Where non-ferrous metals can be replaced by aluminium, the application of aluminium considerably increases(cable production, cooking utensil production). The possibilities for replacement are now nearly exhausted worldwide.

Comparison between the purchase prices of products made of different materials for the same purpose does not base decision for purchase and application. Beside the prices most of the users consider the advantageous properties of aluminium especially if proper convincing product information is available. It can be proved that certain advantageous properties can moderate producing and applying transportation, moving parts and accessories.

Efforts are made worldwide to decrease vehicle's dead weight owing to the considerable rise in the price of energy sources. Essential view-point is to decrease maintenance in the building industry and agriculture.

Calculating method for user's decisions endeavours to take all the effects into account.

The essence of the calculation is that all the costs, - calculated for a desired life-span - such as purchase price + erection costs + transport costs + operating costs + maintenance and other costs, minus returns arising from scrap sale,(- cost -decreasing factors) of the product made of material to be replaced, should be reduced by the time-varying costs (operating costs + maintenance and other costs - cost- decreasing factors) summarized for the same period of the product made of aluminium. The difference gained has to cover the cost of the product made of aluminium.

If this coverage is higher than the fixed, or non-recurring cost (purchase price or production cost + erection cost + transport cost - returns, deriving from scrap sale) of product made of aluminium, the resulting cost difference constitutes savings i.e. profit owing to the use of aluminium. (Costs used to be discounted in the beginning of the period.)

It is not worthy to enforce aluminium application in those fields where end user does not benefit economically from the application of it. If we know the user's requirement concerning the base material of the product we can affect his purchase even if the purchase price of the relevant product is temporarily higher than that of the other product. If he has money for it, if he can get it, etc. These influencing factors, however, cannot be followed by calculating methods.

Manufacturers of aluminium semis are generally not in contact with the end-users but with the manufacturers of finished goods. In spite of this fact aluminium industry is interested in convincing the users to get their needs known in the variety and quality of finished goods, to fulfil their requirements on the side of semi-production. Besides several essential aspects this fact confirms also the efforts that finished goods-manufacturing industry should be an integral part of the aluminium verticum.

Ranking of aluminium application fields and the aluminium finished goods in the aspect of usefulness can be effected unambigously on the basis of economic advantages of end-users. Possibly demand will grow parallel to the covering of costs compared to the costs. It is advisable to compare savings and expenditures.

In some countries of centrally planned economies this index is calculated:

$$\frac{\text{savings}}{\text{expenditures}}\ \%$$

This index gives a sequence which helps the management of economy in the price policy and taxation of finished products.

Consequently, savings by using of different products can be brought to a common denominator if divided with the quantity of used aluminium semiproduct and with the desired life-span. This index gives another sequence which is important for the manufacturer of semis in the forming of marketing policy.

Sequences given by these indices do not unambigously follow each other. In case of some developing countries, at present, none of the rankings may be calculated, but for the development of an aluminium industry it is advisable to calculate both indices as early as possible.

Such a sequence can be modified owing to the change in prices, wages as well as other costs and expenses. Its most essential element is the estimation of the desired life-span, which is not at all exact, and can independently change. In addition, the various users estimate it in different ways. Extraordinarily long life-span may impede even progress.

In all cases the aim of the basic material industry of aluminium is to create a dynamic balance between production and consumption. Realization of dynamic balance in a long period is possible in the frame of long-term development concepts, which take common interests of national economy, aluminium industry and users into consideration.

To promote proportionate progress it is imperative to influence the users' decisions as means of maintaining dynamic balance.

3. Proper selection of materials

The range of mechanical properties of various kinds of aluminium is essentially wider than that of different kinds of steel. For example: the strength of tempered plate of AlMgSi 1 composition is 4.3-fold of that of soft plate of Al 99.5 composition. Its usual price is, however, higher by 13 to 15 % only. Prices of alloyed plates are generally higher by 5 to 10 % than that of unalloyed plates throughout the world. Price of semi-hardened plate is higher by 1 to 2 % than that of hard ones; soft plates are generally cheaper than semi-hardened ones but they are more expensive than hard ones. The specific price of 0.5 mm thick sheet is higher by about 40 % than that of a 5 mm thick plate.

Price of rolled semis is mainly influenced by size, lesser influenced by quality and hardly influenced by state. Prices change to a considerably lesser extent than mechanical properties.

While selecting the material not only the strength alone is essential, but ductility, possibility of surface treatment and weldability, etc. as well, which necessitate a search for an optimal techno-economic solution.

This problem is slightly more complicated in case of rods, tubes and shapes.

If the constructor intends to apply tube, he has the possibility to select among different tubes such as extruded, drawn of strip welded tubes. Here he will encounter the variety of sizes, qualities and states. In case of extruded tubes, rods and shapes the price differences are 20 to 25 % owing to the quality differences. Difference among prices of products of different state but of the same quality ranges between 10 and 15 %. Price of product of minimal cross-section is higher by 30 to 40 % than that of products of maximal cross section if quality and state are unchanged. (Between the two limits there is a minimal price, too.) The price of drawn products is higher by 20 to 25 % only than that of extruded products of the same quality and cross section. Price difference is lower than strength difference, thus application of drawn tube is generally more advantageous for the user than the extruded one, because in case of the same diameter, a tube of thinner wall can be used for a lower specific price.

Welded tube is even cheaper than drawn one. In general, it is advisable to use strip rolled profile too, because rolled profile of thinner wall and smaller cross section may be equivalent to extruded profile.

A guideline such as "the most expensive is the best" may lead to a false selection of aluminium semis. Selection of the proper semis is always a search, comparing mainly, but not only strength and price, for the optimum product. High tensile strength is only recommended if it will result in saving of materials but it is not recommended if its application is not justified by the requirements of the structure or by the finished goods.

In the competition of various structural materials, the position of aluminium can be strengthened by selection of the so called "special purpose alloys" as well as of highly manufactured and properly finished semis.

C. Organization for establishing an aluminium industry

Organization for establishing and developing an aluminium industry has to include a department which will later manage the production, operation and sale, etc.

In the aluminium industry verticality is more dominant than in other industries, especially in case of basic material processing. In the production process of aluminium, primary (basic) raw material is bauxite alone, intermediate is alumina alone, and the ultimate product is aluminium ingot produced from alumina.

Bauxite, alumina and aluminium are interdependent, their ratios of production are determined by physical and chemical relations. Prices of the three products can move in conformity to each other during a long term and they are finally determined by the demand for aluminium.

Verticum of aluminium industry branches out to the following phases in semis manufacturing: rolling, extrusion and casting, etc. Its final phase of manufacturing of finished goods is characterized by the very large number of different kinds of products.

At present, one of the world's most concentrated industry is the aluminium industry. The decisive part of the world's aluminium industry is possessed by a few mammoth companies. Among the independent companies not belonging to these multinational corporations, an increasing number of companies are becoming partly or totally nationalized.

Such kind of unified organization operates efficiently owing to the following facts:

- The verticum is comprehended by one economic unit the activity of which ranges from bauxite prospecting to finished good manufacturing.
- The unified economic organization concentrates

resources, coordinates and organizes development targets and other complex activities.

- The verticum may possess comprehensive innovation base.
- Products of the verticum have good markets because the unified economic organization performs a trade policy which permanently follows the world market changes.

By this unified organizational structure the higher profit (asset proportionate or even weight proportionate) that is realizable on the higher level of the verticum can be the base of the further proportionate development of the whole verticum. It decreases the operating costs by eliminating the stock surplus among the manufacturing phases (this surplus in case of production for external market cannot be eliminated), and results in a decrease of current assets and a possible cessation of cash flow.

At home the organization has to concentrate on one market only and the end users' requirements have to be collated with the manufacturing possibilities of the domestic aluminium industry.

We have already emphasized the importance of this collating activity. In chapter VIII we will return to it. Activities of a department dealing with application technique can be grouped as follows:

- technical consultancy and assistance in solving users' problems such as modern aluminium-processing techniques
- economic consultancy and public relation activities (convincing users about advantageous aluminium applications).

In general, it is advisable to start with a section of the development department dealing with the marketing and techno-economic consulting services which will be available both for the development department and for the users.

This consulting group should include at least the following staff:

- metallurgist
- mechanical engineer
- electrical engineer
- engineer specialist in construction, buildings and civil works
- economist.

It is an advantage when one person has two or more professions in this group for him to cope with a more complex activity.

Future managers of the foreseen production units should be involved in the work of the development organization, prior to undertaking their respective assignments.

Any hesitation of selecting and training these personnel would cause a long delay in fulfilment of the development program and would lessen the efficiency on investment and the future production and marketing of the products.

IV. WORLD WIDE LONG-TERM PROGRESS FOR MANUFACTURING FINISHED ALUMINIUM PRODUCTS

Production of finished aluminium goods means processes by which semis get their final state ready to be used.

Most of the aluminium semis are getting into the processing industry through smaller firms which are able to adapt to the various and rapidly changing requirements of the consumers. Production of finished goods fits only partly into the verticum of producing and processing aluminium. The big aluminium companies of the world process only a smaller part of their semis to finished products. The rest is sold to the processing industry. It is their aim, however, to expand their activities also for producing finished goods either in a direct or an indirect way. Among the many reasons, the following are the most important:

- The technology of finished goods' production is highly aluminium-oriented which means that manufacturing of good-quality final products requires the use of knowledge accumulated in the aluminium industry.
- Production of finished goods needs cooperation with the manufacturers of raw materials and semis.
- Aluminium has a good market in its finished form, the price margin of sales between semis and finished goods is higher than the expenses arising from turning the semis into fully finished goods.
- Finished products of great quantities, and finished products requiring certain semis can be produced by using the technology similar to that of the semis (e.g. roofing material, facade, etc.).
- A considerable benefit may be attained if the scrap

originating in large quantities from the finished products' manufacturing processes is rapidly returned to the processing cycle.

A. The possible product mix

1. Electrical industry

The electrical industry uses aluminium for structures which conduct or do not conduct current. Nowadays the electrical industry applies 15 % of all the aluminium consumption. This amount may increase to 20 % by the Millenium since development possibilites are very notable both in the industrialized and in the developing countries.

In case of current-conducting structures, application of aluminium is justified by the following main aspects:

- Low production cost having a decreasing tendency even for longer term compared to copper.
- Economical application due to its good conductivity and simple maintenance.
- Its applications are reliable.

The main fields of application are:

- Open lines and airlier cables
- High voltage power transmission lines
- Airlier cables (low-voltage distributing grids)
- Armatures
- Telecommunications systems
- Studio equipment
- Subterrain cables
- Telephone cables
- Internal power lines (building electricity)

- Insulated aluminium wires
- Busbars
- Transformers
- Condensers
- Electrical machine windings
- Open air switch gear
- Electric articles for automobiles and vehicles.

The most important aluminium structures not conducting current are as follows:

- Poles of power transmission lines
- Lamp-columns, columns' arms
- Busbar channels, cable channels
- Lighting fixtures
- Aluminium covered switchgears and safety equipment
- Measuring and distribution boxes
- Transformer houses.

2. Packaging industry

This field of application of aluminium consists of production and use of cans, boxes, lids, bottle closures, collapsible tubes, packaging foils, hard-foil trays, sterilizable cups, small containers, barrels, and drums.

75 % of the package materials are utilized by the food processing sectors, so the demands of this branch are of determining character in the consumption as well as in forming the development purposes. There are two kinds of technologies for making aluminium cans:

- They are made of slugs by impact extrusion then lacquered and lithographed.

- They are produced from lacquered, lithographed sheet by deep-drawing.

The method mentioned first requires much material and is of low productivity. The second method is productive and inexpensive, but the height of the sides is, however, limited to 2.5-fold of the bottom radius.

Basic material of the deep-drawn cans is a semi hardened, anodized, lacquered strip of 0.22 to 0.3 thickness. The sides are often ribbed to improve stiffness.

The dimensions of cans produced by the modern technology of side-weakening deep-drawing are more favourable. This technology is mostly applied when producing beverage-cans. Share of using this technology compared to other ones has been increasing by 15 % yearly.

Covers used for cans are generally tearable. For food-preserving jars the lock caps OMNIA or PANO are used. These are made of alloyed aluminium strip lithographed on the one side and lacquered on the other.

Bottles for valuable beverages which are closed and opened several times have screwed caps of the type PILFER-PROOF, TOP-SIDE, etc. Its basic material is a strip of 0.15 to 0.25 mm thickness. The inner side is lacquered. Basic material of the lacquer is epoxy resin. The outer side of the strip is lacquered with inscriptions on it.

The technology of impact extrusion is characteristic of producing collapsible tubes. These tubes are used in the food industry (with closed orifice) and in the package of cosmetics and drugs (with opened orifice).

To reduce the transportation costs conical tubes sliding in each other are also made recently, and usage of aluminium-plastic combined tubes is spreading, as well. Material of the latter is polyethylene-foil-polyethylene coil in hose-form, welded on their sides.

Aluminium foil has become one of the most general basic materials employed in the food industry for packaging. Its usage as basic material is growing quantitatively the best of all. Growth rate of the world's foil production exceeds significantly the general growth rate of aluminium application. Application fields of the various foil-products are shown in the table below:

Table 9.

Application of aluminium foil by the food industry

Description of the foil	Field of application
Blank foil	sweets industry, household foil, prepared food trays
Foil, patterned, with coloured or transparent lacquer coating	sweets industry: chocolate, desserts, bonbons wrapping of wine bottle-necks
Foil with coloured or transparent hot-melt lacquer coating	dairy industry: cheese wrapping
Hard foil with hot-melt lacquer coating, printed	canning industry: lids of jam and marmalade jars
Soft foil with hot-melt lacquer coating, printed	dairy industry: milk and dairy product cup closures
Aluminium foil/vellum paper combination, wet laminated, printed	tobacco industry: cigarette wrapping; coffee and spice bags
Aluminium foil/vellum paper combination, wax-laminated	dairy industry: butter, cottage cheese wrapping vegetable oil industry: margarine wrapping
Aluminium foil/paper combination, wet-laminated, with hotmelt coating, printed	sweets industry: filled wafers, biscuits
Aluminium foil/paper/polyethylene film combination, dry and wet-laminated, printed	soup-powder bags, seasoning bags
Aluminium foil/single or double plastics film combination, dry laminated, printed	canning industry: fruit juices

There is a certain material, similar to foil that is used to produce thin-walled, sterilizable cans and boxes with hot-melt inside coating. Its maximum thickness is 0.18 mm laminated with polyethylene. It is primarily used by the meat industry, but it is also good for packing jam, fruit creams, honey, cheese, etc.

Trays drawn from hard foil and low but wide boxes produced by the same technology are used first of all to pack processed food.

Another large group of aluminium products used in packaging industry is mainly for non-consuming usage. These are boxes, cases, commercial small containers, drums, pallets.

Dimensions of large boxes and small cases generally follow the sizes of normal pallets, but their forms and dimensions are, however, exceedingly varied. They are mainly applied as reusable packing materials, for postal purposes, retail transportation of liquid-, piece-, and bulk goods. Types of cases are:

- collecting cases,
- transporting cases (collapsible and non-collapsible),
- cooling cases.

Aluminium pallets, though being more expensive than the traditional ones, are spreading widely in Europe mainly in internal transportation. Small containers are also used for shop supply: there are also special purpose containers such as aerosol containers, thermos-containers, etc.

The marketed aluminium drums are as follows:

- drums for chemical agent
- drums for food industry

- beer barrels.

Among small barrels of 25 to 100 litres, aluminium drums have mostly dominated the market owing to their simple maintenance.

3. Machine industry

It is a general industrial effort to improve the yield or rather to reduce the material consumption that determines the price of the products.

The specific material consumption of the machine industry is estimated to be 89 % to 95 % of the present one in the year 2000, provided that production is of the same volume and structure. The proportion of steel machine parts will decrease from 86 % to 67-77 %, while the proportion of light metals and plastics will increase from 4.7 % to 13 % according to the prognosis.

The application of aluminium parts in the machine industry is limited owing to the extremely rapid development of plastics and the remarkable fall in the world market prices of alloyed steel in the last years.

Castings and forgings give the biggest part of aluminium consumption in the machine industry. In the countries where the vehicle producing industry is highly developed, foundries generally supply parts for road transportation. Share of other products of the machine industry within the whole consumption is relatively small in those countries where the road vehicle industry is of smaller importance.

Accordingly, attention has to be paid to some other possibilities concerning aluminium application in the machine industry. Consequently, it can be seen that there is a remarkable reserve in aluminium applications within the machine industry where its share in the whole consumption is relatively low. Electric motors, heat-exchangers and miscellaneous mass products are the main users in this category (only the castings of electric motors are counted here, the conductors are not).

The possibilities for aluminium application in developing countries are first of all:

- heat exchangers, engine coolers
- cast components.

The weight of aluminium heat-exchangers of the same capacity is significantly less than those of steel or copper. Thermal efficiency of copper calculated for one unit weight is 40 %, that of steel 15 % taking aluminium as 100 %.

Sizes of the aluminium heat-exchangers of the same thermal output are smaller than that of steel ones. They are spreading widely both in heating and cooling equipment.

The market for aluminium heaters is very restricted in tropical countries, however, it can be taken into account as finished product's export. Heat-exchangers used in air-conditioners and refrigerators could have a good market. The air-side flow-resistance of the equipment due to its ribbed structure is greater but its efficiency is higher. Their most common industrial application is being the cooling component of the air condensation system of thermal power plants. This system enables the setting up of power plants in arid areas. Their aluminium consumption is shown in Table 10.

Table 10.

Aluminium consumption of cooling components

Capacity of the power plant, MW	Aluminium consumption of the cooling component in tons
1,000	2,280
2,00	4,500
3,00	6,800

The application of aluminium is useful in the cooling technique for evaporation and air-cooling condensers of refrigerators. It is a common practice to combine aluminium with steel or copper so that the cooling element on the air side is made of aluminium strip and the material of the primary side is made of steel or copper pipe. Metallic contact is provided for soldered connection. The thermal conduction is perfect and the stability of the whole structure is satisfactory, too.

Specific aluminium consumption of heat-exchangers of the refrigerating industry is 0.3 kg/m^2. Evaporators of refrigerators and refrigerating counters are made exclusively of roll bond aluminium sheets. Their average aluminium consumption is 1.1 kgs/piece.

Another typical ever developing application field of aluminium is its use in the water and oil cooling systems of vehicles. If the ribs alone are made of aluminium and the tubes of copper, 0.1 kg/m^2 consumption of aluminium can be reckoned with.

Perspectively, material of sheet collectors utilizing solar energy will also be aluminium. Solar energy can be employed to heat and cool. This way of utilizing energy sources in our days seems to be the most economic because of the increasing energy prices. The structure of collectors is in many respects similar to the roll bond sheets used in the cooling industry. Their surface is black (without pigment) anodized.

Another large field of the machine industry is the application of cast parts. The rapid upswing in the usage of aluminium castings is justified by both technical and economic conditions. Aluminium castings of great accuracy, requiring no considerable additional work after casting and being easily replaceable, can be produced mechanically to some extent. The capital costs to establish a light metal foundry is considerably lower than that of an iron- and steel foundry.

For different quantities the most economical technologies are:

- sand casting up to 1,000 pieces
- gravity die casting from 1,000 to 10,000 pieces
- different pressure die casting for larger series.

A break-down of the principal casting technologies is illustrated in Table 11.

Table 11.

Break-down of casting technologies

	Sand casting	Manual gravity die casting	Mechanized casting
Industrialized West-European countries	20	40	40
Developing countries	45	50	5

4. Transportation, storage

This field of application of aluminium covers the production of passenger and freight cars, caravans, buses, ships, vehicle accessories, silos, tanks, transport containers, gas-cylinders, etc.

Application of aluminium in the vehicle- and machine industry cannot always be separated. Castings, also discussed in the preceding chapter are mostly employed by the vehicle industry. Of the 2.5 million tons castings, produced annually worldwide, some 1.2 million tons are used as components of cars and motor bikes.

In the passenger cars' production these aluminium castings are to replace first of all iron and steel, and to a lesser degree copper and zinc. Share of some structural materials used in a passenger car is summed up in Table 12.

Table 12.

Share of structural materials in passenger car manufacture

	1980		1990*	
	kgs	%	kgs	%
Steel, iron castings	830	67.0	614.0	56.0
Aluminium alloys	107	8.6	390.0	35.0
Plastics	95	7.6	127.0	11.5
Copper alloys	11	0.9	7.0	0.6
Zinc alloys	5	0.4	3.6	0.3

*estimate

In spite of the high specific cost of aluminium there is a tendency to increase the aluminium consumption in the vehicle production. The reason for this is the effort to reduce the weight of motorcars to fulfil the following requirements:

- planning of energy-saving constructions
- regulations of environmental protections
- personal safety's prescriptions.

It is experimentally proved that a 100 kgs reduction in dead weight has the result of saving 0.7 litre petrol in 100 kilometres. During the whole required endurance period which can be taken as 150,000 kilometres it corresponds to 600 US$. The selling price of a car can be increased only by 25 % of this sum.

It must be stated, however, that application of aluminium leads to the increase of costs. It is the treble of that of cast iron and two to three and a half fold of that of steel. Neverthless, a saving of 75 % can be attained compared to stainless steel.
Using aluminium parts for vehicle construction instead of steel parts usually results in a weight reduction of a ratio of 1: 2 or even 1 : 2.5.

It is to be expected that the regulations concerning the environmental protection will be obligatory in Europe, too. (Maximum permitted consumption in 1980 was 11.8 litres/100 kilometres and it will be 8.5 litres/100 kilometres in the USA in 1985.) This prescription will promote reduction in the dead-weight of the cars.

The application of castings will remain but the appearence of forged components has also to be taken into consideration. Application of body plates has shown a notable upward tendency from the mid eighties and usage of extruded profiles (fenders, decorating strips) will be growing, too.

Considering that plasticity of aluminium plates assuring proper stability is behind that of steel that can be deep-drawn, changes in body construction become necessary. The time needed to introduce such changes is estimated to five years or so.

These tendencies will dominate practically in lorries, buses and service vehicles. Though being fewer in number than passenger cars, they require more material per piece because of their heavier weight.

Economic efficiency of aluminium construction applied to superstructures of lorries and buses is secured not only by reducing the weight but also by the favourable maintenance costs and endurance. An interesting development is the exchange of steel/wood combined superstructures for aluminium ones. The aluminium bodywork consists of extruded aluminium sections to be pushed into one another and fixed by a latch resulting in remarkable manpower saving. The production cost will practically be the same as that of steel/wood combination with the extra benefit of not needing skilled manpower.

Application of aluminium in railway cars and carriages is - besides the already known inside equipment (luggage-grids, handholds, window-frames, handlers) and outside appliances such as roofs, mobile separation walls like railway car doors, door covering for bulk transports - constantly the question of the day. If the chassis and carcases are made of extruded, alloyed profiles, not only the weight can be reduced but also saving in production and maintenance costs can be achieved. Weight reduction has the advantage of causing reduced wear in running-gear and trackage and in the case of a collision the shock absorption of aluminium is good. Among vehicles rolling on rail these advantages are proved in serial production of the underground train carriages.

It is the reduced weight, the corrosion resistance and the simple maintenance that are good reasons supporting the application of aluminium usage for vehicles and transportation facilities alike.

Processing technology of tanks, carrying liquids, and bulk goods are practically the same as that of stable tanks, silos, etc. It is their dimension and wall-thickness that are different first of all. Pressure tanks and tanks of static loads are made of aluminium. The main consumers of such tanks are the chemical industries, industry of synthetics, food processing and the agricultural industries.

Aluminium tanks are employed by breweries not only for storage, fermentation and transportation, but also for saturation of beer with carbon dioxide. Boiling vessels are also made of aluminium replacing tinned copper.

The outer hull of the double-walled equipment in dairy industry is made of aluminium and their inner body - being in direct contact with milk - is made of stainless steel.

The prospects to produce tanks, bottles, cylinders, suitable for transporting liquid gas (PB-Gas) are very good.

The so called big containers (larger than 5 m^3) are not so widespread due to the strict ISO requirements. There are only two firms producing these all over the world. They produce 20 feet long containers.

5. Building-industry

Constructions and finished products of building-industry are of many kinds regarding both requirements and structural appearance.

Application fields in building and construction where aluminium semis can advantageously be employed due to their light weight, corrosion resistance, and good ability to block humidity and favourable reflectivity include:

- inside and outside cladding
- aluminium foil to preserve against humidity
- framed constructions
- doors, window frames, bars
- cooling components.

The volume of aluminium consumption in building industry of a country depends mainly on the national income.

The correlation is not too strict. Conventional building methods are no longer able to meet growing demands concerning both quantity and quality.

Table 13.

Relationship between national income and aluminium consumption in the building industry

National income per capita $	Consumption per capita kg
<800	-0.7
800-1,000	0.7-2.0
>1,000	2-6

This calls for a thorough revision of conventional architectural thinking throughout the world, with more sophisticated building techniques, prefabrication and light constructions.

General advantages of these methods are the following possibilities:

- Prefabrication can be applied in areas where a more advanced stage of industrialization and the necessary infrastructure already exist.
- Built-in volumes of material may be reduced by about one tenth.
- Assembly and installation work on the spot require fewer skilled labour.
- Completion of projects may be short-cut.

The greater part of semis produced by so called high-finish are made for the purposes of building industry:

- various patterned sheets
- lacquered sheets
- corrugated sheets
- perforated sheets
- profiles bent from strip
- heat isolated panels.

Aluminium industry itself ,often produces certain construction, such as:

- windows, doors
- air grids, refuse sheets, rain gutters,
- roofings
- suspended ceiling (element systems), separating walls,
- garages, stores,
- room elements (container buildings),

- complete buildings, deep-feezing storage houses.

Prime contracting is the highest activity phase of the aluminium industry in building and construction, it covers the whole feasibility of complete industrial, agricultural and public buildings. Two systems are used at present:

- The so called mobile homes, a sort of dwelling containers. These are completely prefabricated and so delivered to the site of setting up.
- The module system enabling the mounting of prefabricated framing, roofing, side panels, window frames and doors on site.

The former method requires minimal work when assembling but combination possibilities are restricted, but it is important still for buildings to be moved to another place if required.

6. Chemical industry, agriculture, food processing

70 % of aluminium semis used in chemical industry is plate or strip, 20 % is extruded product and 10 % is foil.

Temperature range of application is between -196 and 200 C°. Some special examples of aluminium usage in the chemical industry are as follow:

- Good results have been reached in oil- and petrochemical industry: bundles of aluminium tubes for heat condensers, heat exchangers and coolers used to remove H_2S by washing with ethanol or glicolamine moreover strippers for H_2S-NH_3 as well as aluminium tube bundles of head condensers in lubrication oil refinery with methyl-ethyl-ketone.
- Pure aluminium equipment (about 30 % of total) are used to produce acetic acid and acetic acid anhydride resp. The acetic acid of 98-99,5 purity is stored in aluminium

tanks up to 80 C^o.

- Condensers and coolers (about 40 % of total) of the salt-free side of desalination equipment for salt (sea) water are made from aluminium.
- For tubes and pressure vessels of cryogenic equipment (air condensation, separation of synthesis end gases, etc.) AlMg alloys with 3-5 % Mg content are used besides copper.
- Material of storage silos for plastic granules and powder is AlMg alloy.
- Double tubed (aluminium/steel) air-cooler with ribbed pipe is used in petrochemical and fertilizer industry.

Varieties of pure and alloyed aluminium explosively bonded to steel plate are applied to a growing extent by which the limits of use become considerably wider.

The aluminium has not worked well in HCl, NaOH and solutions containing chloride salts or agents with heavy metals (Hg, Cu, Cb, Ni, Pb, etc.) even if only in traces. It is also critical to use aluminium if in contact with these heavy metals it causes a galvanic effect.

In the food industry canneries use aluminium in form of storage utensils, tanks, tubes, slides, troughs and feed funnels. In the dairy industry some of the technological equipment and the milk cans are made of aluminium. In the meat and sugar industry we can meet aluminium in technological equipment as well as in conveyors and protective, heat insulating covers of open air lines. In the milling and baking industry silos with smaller capacity (max. 50 m^3), machinery platforms and transporting containers e.g. bread transporting containers are made of aluminium.

Because of the usually rough handling and unfavourable local conditions, quality standards of aluminium items used by agriculture are in most cases high and exacting. Aluminium can fulfil these norms in many cases.

Irrigation systems in agriculture are of different character according to whether they are used in gardening or on arable land. Their design also depends on whether they are employed as rainers, sprinklers or as subsoil irrigation systems.

Aluminium pipelines are usually used in largest quantities on arable land for rainees. They may be re-siteable, self-propelling or trailable, but their common feature must be: mobility.

Aluminium has only a complementary role besides plastics in subsoil and sprinkler irrigation systems.

Greenhouses in gardening can be very favourably used: being independent of weather an optimate climate is secured for the plants. This means heating, keeping of optimal moisture and carbon dioxide content in continental climates while in torrid zone cooling is the most important. There is a possibility - with help of these greenhouses - to grow such plants, that would not grow otherwise in the given climate.

The cheapest way of making such greenhouses is using a framework clad by two plastic foils so that sprinkling of water between the foils can assure heating, or cooling. Frameworks employed in greenhouses are made of welded or extruded drawn aluminium pipes.

In large-scale production of viniculture the vine-yard grape-poles, and supports are also made of welded pipes or profiles bent from strips of agricultural aluminium frameworks, too.

7. Household utensils

This group includes the production of

pots and pans

pressure cookers

autosyphons

office and camping furnitures.

Considering the history of aluminium consumption and finished good manufacture, we can state that production of pots and pans preceeded the production of other finished goods everywhere.

Conventional aluminium utensils, though having been used already for some decades, are on the market even today, and presumably will find a market in the future, too. The producers provide it with continuous development.

The various utensils: coloured, anodized, enamelled and plastic clad ones enlarge the collection beside those having natural colour. Pressure cookers are next in line.

Sodasyphons, for example, cannot be imagined to be manufactured of anything else, but aluminium. Similar technology is used when preparing whipped-cream in so called cream-syphons with a certain combination of plastics.

Aluminium framework of office furnitures include wooden or plastic sheets, doors, and drawers. The usual combination for camping furniture is aluminium, textile and plastic.

8. Mass products

Industry of mass products includes the production of various goods with a large variety

Their common properties are that:

- they satisfy mass demands independent of their application areas,
- manufacture of each product is performed in medium or large series respectively.

The most important product groups are:

- aluminium ladders, movable platforms
- bonding elements (nails, screws, rivets, etc.)
- gas-containing vessels from aluminium (for industrial, household, automobile and sport uses)
- street equipment (garbage can, street markings, street barrier, fence)
- home equipment (racks, hat-and-coat stands, picture frames, curtain rods, TV antennas)
- hygenic means (strecher, wheel chair, etc.)
- jewelry, knick-knacks, fancy goods
- sporting goods (boat, tourist equipment, etc.)

Mass type products can be economically manufactured only in large series; produced quantities generally exceed the internal need of a country. These are products to be exported and, accordingly, their design and surface treatment is of great importance.

B. Substitution of copper, tin-plated and/or zinc-coated steel

Competition among the various structural materials has already been discussed in Part IV.

Development work in the past 40 years tended to produce goods, substituting those made of conventional structural materials. This process notably contributed to looking at aluminium as a sort of "substitute" but this definition has a pejorative meaning. Also, the simple substitution possibilities are mostly over in the industrialized countries. To enlarge the consumption new products, entirely new application fields are needed.

Development work in order to find substitute materials has considerable possibilities in countries where there are technical sources available and the market is not oversupplied. The tendencies are influenced chiefly by the reserves of raw materials, the degree of supply of structural materials and the industrial and economic structure.

In electrical engineering aluminium is very good for replacing copper. In many fields of packaging tin and tin-plated-steel are substituted by it, and aluminium can be used instead of zinc and zinc-coated steel in the building industry, too. In our days it is the vehicle industry, where aluminium becomes used in large quantities instead of steel and cast iron.

Aluminium is more expensive than steel, therefore its usage is somewhat hindered, whereas it being relatively cheaper than copper, aluminium could replace it with success in many branches of the industry. Whether aluminium can take the place of copper, is nowadays practically a question of technique.

Resistance and price of 1 kg conductor, e.g. cadmium bronze, is 2.28 fold and 1.4 to 2.- fold respectively, compared to that of aluminium. These indices make application of aluminium conductor quite obvious. Electrical conductor manufacture is now strongly aluminium oriented.

This can be stated from the fact, that the share of the aluminium conductors manufactured in many countries is about 50 %. Comparing the heat-transfer of ribbed plates in heat-exchangers made of various metal sheets, application of aluminium proved to be substantiated:

commercial aluminium sheet	3,400 kcal/h.kg
aluminium alloy sheet	3,000 kcal/h.kg
copper sheet	1,250 kcal/h.kg
commercial steel sheet	500 kcal/h.kg

Tinned-steel sheet may be replaced primarily in food processing industries (cans, glass jar tops). There is a tin shortage in the world market and so it is getting more and more expensive. Money spent on up-to-date packaging material and constructions often exceeds the value of the packaged goods itself, development of packaging might result in reduction of production cost.

For example:

Weight of one can of 240 ml volume

made of tinned steel sheet	77 grams
made of aluminium	27 grams
made of aluminium foil	15 grams

It is not by chance that aluminium used for can and box production was subject to a fivefold rise in the last 10 years, while tin-plate had only a 1.5-fold growth. Counted in pieces, the growth is much greater considering the to weight ratios.

Using 1 ton aluminium in building industry means an average savings of 2.4 to 2.6 tons steel sheet and 0.2 to 0.25 ton zinc. Aluminium structures (roofs, side-walls, rain gutters) are generally more expensive regarding production cost. It must be stated that durability of aluminium sheet is much longer than that of zinc-coated steel, and zinc coated steel has to be surface-treated (painted), too.

In contention - between aluminium and zinc-coated steel plate - application of aluminium is more favourable in all cases the required life-span of the construction is expected to be more than 4 years.

Aluminium is no more regarded as a "substitute" material concerning the application fields mentioned above. On the contrary, it is the proper material and this is reflected by the large fields of its application.

V. A SHORT-TERM PROGRAM FOR MANUFACTURING ALUMINIUM FINISHED PRODUCTS

Establishing a verticum in the aluminium industry is a long-term procedure. There are two possibilities of doing so:

1. Starting from bauxite mining, through alumina production and aluminium smelting, to semis manufacturing.
2. Starting from finished goods manufacturing to semis manufacturing and aluminium smelting.

Aluminium metallurgy is the biggest energy-consuming and the most device-intensive phase of the verticum. It requires, however, the least manpower. Finished goods manufacturing is the least device-intensive but has the largest manpower requirement in the verticum.

If we consider the volume of the market activity, aluminium basic-products require the least marketing activity while the world market price fluctuations have immediate effects. It could be considerably profitable to maintain proper and advantageous ration among manufacturing, stockpiling and selling; but both businessmen and manufacturers can suffer, however, considerable losses working in the free market. If finished aluminium goods manufacturing plants, running not entirely independently of each other, have a sufficient wide range of product assortment and can smoothly change their profiles, manufacturing of finished goods implies smaller risk. Selling of finished goods requires considerable marketing activity owing to the wide range of assortment and the small quantity of a given kind of product.

In our opinion, it is not advisable to postpone development of finished goods manufacturing till it can be fully provided with indigenous raw materials. Above all, satisfying the finished goods' requirements fully from import is not economical, too.

We wish to propose to establish aluminium goods manufacturing plants by which indigenous manufacturing can be started which would be appropriate for the fundamentals of the aluminium industry.

A. Some recommended products and workshops in particular

1. Small plant for manufacturing aluminium household utensils

Aluminium household utensils listed below or any other products requiring the same technology can be produced in the plant.

Name	Size /cm/	Pieces/year
Pot	14, 18, 22	50,000
Pouched pan	14, 18, 22	50,000
Lid	14, 18, 22	10,000
Frying pan	18, 20, 22	30,000
Tea-kettle	14, 16, 18	40,000
Dinner-carrier (with 2, 3 and 4 bowls)	14, 16, 18	30,000
Bowl		50,000
Tourist pan	16	40,000
		370,000

Material requirements:

Aluminium circle	105 t
Steel (sheet, strip, wire)	33 t

Auxiliary materials

paint	5 t
caustic soda	3 t
nitrous acid	1,5 t
abrasive paste	10 t

Total weight of finished goods: 135 t

Operations of manufacturing technology are as follows:

a/ Cold working without machining

a/1 Straightening, cutting to size

- straightening and cutting of wires, coils and straight materials

a/2 Strip forming to pipe, cutting to size

- strip forming and cutting to size of tea-kettle clips and utensils' iron handles

a/3 Cutting by band saw

a/4 Deep drawing

- drawing operations on hydraulic extrusion presses: bowl and lid drawing

a/5 Cutting by circle shears

- cutting of drawn parts by circle shears

a/6 Cutting by eccentric press

- cutting, bending, flattering, striking, blanking, punching

a/7 Metal shaping, cutting, flanging

- shaping operations from circle with or without prestressing on metal-shaping machines by hand tools a/8 Smoothing, planishing

- smoothing, planishing of prestressed workpieces by planing machine

b/ Machining

Drilling, counterdrilling, thread drilling, milling (tea-kettle spout milling), grinding, deburring.

c/ Chemical processes

Acid and basic production operations for the technology of:

- degreasing
- picking
- phosphate coating

d/ Surface finishing

d/1 Finishing

Surface treatment by finishing machines of horizontal or vertical shaft by means of abrasive cloth (inner and outer finishing)

d/2 Polishing

Polishing by polishing machine of two rag buffing wheels (at each end of shaft)

d/3 Abrasive tumbling

e/ Casting

Casting of tea-kettle spouts from pot metal using scrap.

f/ Assembling

Assembling of two or more parts:

- soldering (tea-kettle spout)
- rivetting

- other manual assembling steps

g/ Painting

Surface protecting and finishing processes

- varnishing
- burning-in

h/ Cleaning

Cleaning the surface of product from manufacturing impurities.

i/ Packaging according to requirements.

Table 14.

List of machines and equipment of a household utensils manufacturing plant

Item No.	N a m e	Pieces	Built-in power, kW	Mass kgs
1.	Extrusion press for deep-drawing (PYE 100S/1)	2	30.0	7,200
2.	Eccentric press (DKS-40A)	5	20.0	12,500
3.	Planing machine (E 400 M)	1	5.5	2,600
4.	Metal-shaping press	1	5.5	2,600
5.	Circle shears	1	2.0	150
6.	Universal machine (E 400 M)	1	5.5	260
7.	Pickling+phosphate coating bath line	1	108.0	1,200
8.	Finishing machine with horizontal shaft	1	2.0	150
9.	Finishing machine with vertical shaft	1	2.0	150
10.	Finishing-polishing machine with double shaft	2	16.0	1,000
11.	Special air puncher	1	-	200

con'd

Item No.	Name	Pieces	Built-in power, kW	Mass kgs
12.	Special rivetting machine	3	4.5	600
13.	Soldering equipment	1	-	100
14.	Casting ladle TCAL 50	1	21.0	1,740
15.	Band saw	1	1.5	200
16.	Aggregate for tea-kettle spout milling	1	2.5	150
17.	Grinding machine with double shaft (K-301) (deburring)	1	1.1	140
18.	Drilling machine (F 013)	1	0.55	150
19.	Strip forming (to pipe) machine	1	3.5	300
20.	Abrasive drum	1	1.5	150
21.	Straightening-cutting machine	1	2.0	100
22.	Dip painting equipment with burning-in box	-	-	200
23.	Burning-in kiln	2	64.0	6,000
24.	Paint spraying box	1	2.0	260
25.	Cutting machine (to rectangular size)	1	3.0	400
26.	Special flanging machine	1	3.0	400
27.	Straightening-cutting machine	1	2.0	100
28.	Exhaust fan	5	16.0	500
1-28.		41	325.0	41,840

Total price of installation: US$ 412,000.-

The total area required for the plant including casting shop, chemical and finishing plant's units requiring separation as well as storage area among various operations:

cca 950 m^2.

Power requirement of the plant

Electric power (built-in):	325 kW
Note: If heat energy for chemical operations (bath heating) is available in form of steam, built-in electric power requirement:	217 kW
and steam requirement:	1 t/h
Compressed air	15 m^3/h
Water	3 m^3/h
Tooling cost requirement (non-recurring cost)	US$ 172,000.-

Productive manpower requirement

Metal pressing skilled workers	2 persons
Finishing skilled workers	3 persons
Semi-skilled machine workers	14 persons
Other semi-skilled workers	7 persons
Totally	26 persons

If buildings and infrastructure are available or they can be constructed on the spot from local materials, cost of plant is the following:

Machine and equipment	US$ 412,000.-
Tooling	US$ 172,000.-
Know-how	US$ 46,000.-
Total	US$ 630,000.-

Workers' training costs are added to this value. Cost can be decreased if main parts such as bodies of pots, pans and kettles as well as lids are manufactured only, while smaller parts such as handles, handle-supports, tea-kettle spouts are produced by a subcontractor or from the company supplying the know-how, under a long-term cooperation agreement. In this case the equipment and built-in power requirement decreases as follows:

Item No.	Name	Pieces	Built-in power, kW	Mass kgs
1.	Extrusion press for deep-drawing (PYE 100S/1)	1	15.0	3,600
2.	Eccentric press (DKS-40 A)	1	4.0	2,500
3.	Planing machine (E 400 M)	1	5.5	2,600
4.	Metal-shaping press (E 400M)	1	5.5	2,600
5.	Circle shears	1	2.0	150
6.	Universal machine (E 400 M)	1	5.5	1,600
7.	Pickling+phosphate coating bath line	1	108.0	1,200
8.	Finishing machine with horizontal shaft	1	2.0	150
9.	Finishing machine with vertical shaft	1	2.0	150
10.	Finishing-polishing machine with double shaft	2	16.0	1,000
11.	Special air puncher	1	-	200
12.	Rivetting machine	2	3.0	400
13.	Soldering equipment	1	-	100
14.	Exhaust fan	4	13.0	400
1-14.		19	181.5	17,650

Consequently the cost of machines and equipment	US$ 177,000.-
tooling	US$ 94,000.-
know-how	US$ 29,000.-
Total	US$ 300,000.-

2. Small plant to manufacture transport milk-cans of aluminium

Transport milk-cans of 25 litres and 40 litres or any other products requiring the same technology can be produced in the plant.

Operation of manufacturing technology are as follows:

a/ Cold working without machining

a/1 Deep-drawing

Drawing operations by crank and hydraulic extrusion presses

a/2 Cutting by circular saw

a/3 Cutting of drawn parts by circle shears or by special cutting machine

a/4 Press forming

Shaping operations on pre-stressed workpieces by special neck-forming machine

b/ Machining

Turning, drilling, milling, deburring

c/ Chemical surface treatment (pickling)

Acid and basic manufacturing operations

d/ Casting

The milk-can manufacturing plant does not have a casting shop. Consequently, the cast parts (neck ring, bottom ring, closing clip, lid base) are to be provided for.

e/ Assembling

Assembling of two or more parts by

- welding

- rivetting
- other manual assembling method

Table 15.

Equipment and built-in power requirement and water consumption of a milk-can manufacturing plant

Item No.	Name	Type	Pieces necessary for production of		Power kW	Water m^3/h
			25,000 units	100,000 units		
1.	Extrusion press for deep-drawing	HZPU 200 hydraulic press	1	1	74	1
2.	Extrusion press for deep-drawing	160 t Shuller	2	2	60	-
3.	Extrusion press for deep-draving	PYE 100 t	1	1	15	-
4.	Lathe	RT 40	2	5	11 (27)	-
5.	Upright drilling machine	FO-13	1	3	0.55 (1.7)	-
6.	Pickling bath line	consisting of 5 wooden baths	1	1	80	2.5
7.	Oil press	special oil press	1	2	5 (10)	-
8.	Welding apparatus	T.I.G.	1	1	-	-
9.	Finishing machine	K-352	1	3	3.6 (10.8)	-
10.	Circular saw	plastic diss circular saw MTD-300	1	1	2.7	
11.	Cutting machine	special cutting machine	1	1	2.5	-

con'd

Item No.	Name	Type	Pieces necessary for production of		Power kW	Water m^3/h
			25,000 units	100,000 units		
12.	Low-frequency annealing furnace	special annealing furnace	1	1	50	-
13.	Neck-shaping machine	special shaping machine	1	3	4 (12)	-
14.	Lathe	EE 500-0.1	1	1	13	
15.	Eccentric press	DKS-25/a	1	1	3	-
16.	Milling machine	special milling machine	1	1	0.5	-
17.	Milling machine	special milling machine	1	1	0.5	-
18.	Circle shears	special circle shears	1	1	0.5	-
Total			20	30	326 (61.5)	3.7

It can be seen from the Table that utilization of some machines and equipment is not adequate in case of manufacturing small quantities. If 25,000 pieces of milk-cans are manufactured yearly, in one shift, there are considerable unutilized machine capacities. If 100,000 milk-cans are manufactured yearly, utilization factor of machines is improved.

Large household utensils up to 90 litres can also be advantageously manufactured by this manufacturing line. In addition, the remaining capacity can be utilized to manufacture utensils of normal sizes.

Area requirement of the plant including chemical plant unit requiring separation and storage area among the various technical operations.

Table 16.

Operational conditions of a milk-can manufacturing plant

	Capacity	
	25,000	100,000
	pieces	
Area, m^2	850	1,000
Electric power (built-in, kW)	326	388
Water-consumption	3.7 m^3/h	
Natural gas	4.0 m^3/h (if hot steam can be used for chemical operations and bath heating, 1 t/h steam substitutes 80 kW electric power)	
Productive manpower requirement:		
semi-skilled machine workers	6 persons (20 persons)	
other semi-skilled workers	6 persons (20 persons)	

If the number of workpieces increases 4-fold the manpower requirement will be 3.3-fold only.

Table 17.

Aluminium requirement for milk-can producing plants of different capacities

Capacity (number of pieces)	25 lit milk-can	40 lit milk-can
25,000	150 t	225 t
100,000	600 t	900 t

Cost of machinery, first tooling and know-how:

US$ 1,300,000.-

Thereof:

machinery	US$ 970,000.-
tooling	US$ 100,000.-
know-how	US$ 80,000.-
setting and start-up operation	US$ 150,000.-

3. Plant for manufacturing aluminium cylinders for P.B.-gas

Gas cylinders of capacities between 16.2 litres and 50 litres and car gas bottles of 60 litres can be produced in the plant.

Technologies are as follows:

- cold working (drawing, bending, inscription text stamping)
- machining (turning, milling)
- welding
- heat treatment (hardening)
- surface treatment (pickling)
- laboratory quality tests (pressure test)

Table 18.

Sequence of operations of cylinder manufacturing technologies

Base material: disc

	Operation	Machine - equipment
1.	Drawing - cutting - opening-annealing - opening-reducing	1300 MN SNG manufacturing line
2.	Opening turning	Special lathe
3.	Pickling	Pickling line
4.	Welding of the fittings (neck ring, bottom ring protective basket)	AGA-Miller welding machine
5.	Pressure test	Special equipment
6.	Heat treatment (hardening)	KGYV electric pusher type furnace
7.	Heat treatment (ageing)	KGYV electric pusher type furnace
8.	Pickling	Pickling line
9.	Final acceptance tests	Special line for acceptance test
10.	Painting (marking stripe)	Painting equipment

Table 19.

Sequence of operations of neck-ring manufacturing technologies

Base material: forged semi-product

	Operation	Machine - equipment
1.	Text stamping (in case of 50 lit gas bottle)	2500 MN PYE hydraulic press
2.	Machining I	1314 capstan lathe
3.	Machining II	1314 capstan lathe
4.	Thread milling	GFU-16 MECANA thread-milling machine
5.	Pickling	Pickling line
6.	Assembling (welding to the bottle)	AGA-Miller welding machine

Table 20.

Sequence of operations of bottom ring manufacturing technologies

Base material: extruded semi-product

	Operation	Machine - equipment
1.	Cutting, punching, preliminary bending	350 MN eccentric press
2.	Final grinding	Stand grinder
3.	Rounding	Special rounding machine
4.	Welding	AWI welding apparatus
5.	Calibration	350 MN eccentric press
6.	Pickling	Pickling line
7.	Assembling (welding to the bottle)	AGA-Miller welding machine

Table 21.

Sequence of operations of protective basket manufacturing technologies

Base material: extruded semi-product

	Operation	Machine - equipment
1.	Cutting	Circular saw
2.	Text stamping	2500 MN PYE hydraulic press
3.	Window punching	350 MN eccentric press
4.	Preliminary bending	350 MN eccentric press
5.	Rounding	630 MN hydraulic press
6.	Punching	350 MN eccentric press
7.	Final embossing (two)	350 MN eccentric press
8.	Deburring	Stand grinder
9.	Pickling	Pickling line
10.	Assembling (welding to the bottle)	AGA-Miller welding machine

Manufacturing technology of 60 litre car gas cylinder is the same as applied for manufacturing the above gas cylinder without bottom ring and protective basket but with supplementary gadgets.

Table 22.

Sequence of operations of locking cap manufacturing technologies

Base material: circle

Operation	Machine - equipment
1. Drawing	2500 MN PYE extrusion press
2. Cutting to size	Special lathe
3. Pickling	Pickling line
4. Assembling	AGA-Miller welding machine

Table 23.

Sequence of operations of connecting end manufacturing technologies

Base material: slab

Operation	Machine - equipment
1. Turning	1314 capstan lathe
2. Drilling	Table drilling machine
3. Thread drilling	Table thread-drilling machine
4. Pickling	Pickling line
5. Assembling	Special AGA-Miller welding machine

Table 24.

Summarized list of machines and equipment for manufacturing PB-gas cylinders

Item No.	Name	Pcs.	Source of procurement
1.	1300 MN SMG drawing line	1	FRG
2.	KGYV electric pusher type furnace	2	Hungary
3.	AGA-Miller welding machine	6	Sweden
4.	Pickling line	2	Hungary
5.	Testing line	1	Hungary
6.	1314 capstan lathe	2	USSR
7.	GFU-MECANA thread milling machine	2	Switzerland
8.	350 MN eccetric press	6	Hungary
9.	2500 MN PYE hydraulic press	1	GDR
10.	630 MN hydraulic press	1	FRG
11.	AWI welding apparatus	1	Sweden
12.	Stand grinder	2	Hungary
13.	Special painting machine	1	Hungary
14.	Cutting machine with circular saw	1	Hungary
15.	Special lathe for openin turning	1	Hungary
16.	Special rounding machine	1	Czechoslovakia
17.	Material-handling equipment		
	- conveyor belt	3	
	- manual and mechanized trolley trucks	6	
	- crane (above SMG drawing line)	1	
18.	Exhaust fan and air conditioning		Hungary
19.	Laboratory test equipment		Hungary
	- to measure hardness	1	
	- to tear and bend	1-1	
	- X-ray equipment	1	
	- to tear	1	
20.	Other equipment		Hungary

Estimated total price of equipment: US$ 3,940,000.-

Additional equipment to manufacture car gas cylinders:

21.	2500 MN PYE hydraulic press	1	GDR
22.	AGA-Miller special welding machine	1	Sweden
23.	Table drilling machine	1	Hungary
24.	Table thread-drilling machine	1	Hungary
25.	Lathe (cutting to size)	1	Hungary

Cost of the above additional equipment:	US$	214,000.-
Cost of first tooling:	US$	470,000.-
Cost of know-how:	US$	370,000.-
Cost of establishing the plant without infrastructure:	US$	4,994,000.-

Area requirement of the plant: 3,500 m^2 (recommended length and width 70x50 m)

Power requirement:	electric (built-in)	1,500 kW
	heat - steam (technological)	4 m^3/h
	water	15 m^3/h
	air 6 to 10 att.	25 m^3/h

If pickling baths are not heated by steam built-in electric power requirement is: 1,750 kW.

Productive manpower requirement: directly engaged 60 persons/shift
indirect (other) 12 persons/shift

In case of 2 shifts capacity of the plant is 250,000 pcs/year. By installing some additional machines capacity can be easily increased to 400,000 pcs/year.

Aluminium-consuming requirement can range between 2,000 and 8,000 tons/year depending on the assortment and volume of the products.

4. Small plant to manufacture aluminium beer barrels

Reviewing the lists of equipment of plants manufacturing household utensils, transport milk-cans and gas cylinders, it can be seen that the equipment required for plants manufacturing different products overlap.

Base machinery such as drawing extrusion presses, drawbenches, eccentric presses facilitate cold working. Bodies of utensils can be manufactured in the milk-can manufacturing plant, too; milk-cans and utensils can be manufactured in the gas cylinder manufacturing plant, as well. If several products are manufactured in parallel, the capacity of the plant decreases considerably. If a gas cylinder manufacturing plant produces utensils as finished products, the machinery indicated in para V. 1 but not included in Para V. 3 is also required. In case of such parallel manufacturing, the total capacity of this machinery will not be utilized.

Beer casks are also manufactured by cold working. The characters of the equipments are similar to that of gas cylinders manufacturing plant. For example, beer barrels (casks) consisting of two parts are also welded by an automatic welding machine. A special equipment is required to varnish the inside wall of the cask.

Summed up cost of a small plant manufacturing 40,000 beer casks/year is, including main machinery, first tooling and know-how, without the detailed description of technology and equipment:

US$ 1,563,000.-

Barrels (casks) of 50 litres and 100 litres can be produced in the plant.

Material requirement:	400 tpy	for	50 litre casks
	950 tpy	for	100 litre casks

5. Small plant to manufacture aluminium soda water syphons

1 litre soda water syphons and 0.5 litre cream syphons for cream or fruit cream can be manufactured in the plant. To use the syphons, cartridges containing CO_2 and N_2O are needed.

The bottles and heads are made from aluminium and plastics respectively. Surfaces are polished, sand blasted and anodized.

There are two manufacturing technologies: deep drawing or cold working. Base material for the latter is slug cut from extruded aluminium rods. Cold working extrusion presses are similar to extrusion presses used in the munitions industry for making cartridge cases.

Capacity of the proposed plant:

500,000 pcs/year (250,000 pcs soda water syphons +
+ 250,000 pcs cream syphons)

Material requirements:

aluminium	350 t/y
plastics	56 t/y

Cost of machinery including tooling and know-how:

bottle manufacturing	US$	2,200,000.-
head manufacturing	US$	250,000.-

Manufacturing costs in case of deep drawing are higher than those of the cold working. Consequently, home price as well as export price of the product will be higher, too. Despite greater unit prices, marketability, volume of the mass production, return on sales and magnitude of profit will decrease.

Adaptation of deep drawing technology is only justifiable in the period of introducing the product at the market, when the hardware or gas bottle's plant is already operating at fractional load; the manufacturer accepts responsibilities for marketing at a lower price till start up of the syphon plant in order to gain the market.

6. Aluminium heat-exchangers' manufacture

In this plant, small ribbed (finned surface) heat exchangers and radiators can be produced from extruded aluminium shapes and strips.

Capacity of the plant: 200,000 m^2/y
Material requirement: 750 t/y
Estimated price of main machinery including tooling and know-how: US$ 780,000.-
Manufacturing technology:

- cold forming (strip cutting, rib forming /finning/),
- machining (turning, thread cutting)
- welding
- finishing (pickling, painting).

Finned surfaces are preferably used at aluminium heat exchangers and cooling elements in the power generation industry. This allows building power plants everywhere, even at arid sites, because cooling the water of the steam turbine condensers can be accomplished with forced circulation in cooling elements as a closed circuit.

Finned cooling surfaces can be used for any kind of industrial cooling as well, e.g. for compressor stations of gas- and oil pipe-lines, or for coolers in chemical industry.

Finned surfaces are also used at aluminium radiators.

7. Plant for manufacturing aluminium lamp posts and lamp arms

Stepped diameter roadside aluminium lamp posts with or without arms can be produced in the plant for public lighting and other purposes (e.g. posts for supporting low, and middle voltage network and traffic lights, etc.).

We propose to produce the lamp posts according to the following percentage break-down:

Table 25.

Percentage break-down of lamp-post manufacturing plant

Item No.	Name	Length m	%	Remark
1.	Lamp-posts of single stepped diameter	3.1	20	for traffic lights
2.	Lamp-posts of single stepped diameter	4.2	20	for floodlight with arms
3.	Lamp-posts of single stepped diameter	5.1	6	lamp to be mounted on top of the post
4.	Lamp-posts of single stepped diameter	6.5	6	lamp to be mounted on top of the post
5.	Lamp-posts of double stepped diameter	7.8	8	lamp to be mounted on top of the post
6.	Lamp-posts of double stepped diameter	9.6	40	single- or double arm mounted on top of the lamp post

Base material: aluminium tubes.

Dimensions of some aluminium tubes:

- diameter 160 mm, wall thickness 6 mm
- diameter 180 mm, wall thickness 6 mm
- diameter 90 mm, wall thickness 6 mm

For lamp-posts of 180 mm diameter at its bottom, additional elements such as casting tube and extruded door profile are required.

Material quality: Al Mg Si Cu mild.

The plant should be operated in 2 or 3 shifts. Accordingly the expected capacity of the plant would be 20,000 and 35,000 pcs/y respectively.

Manufacturing technology:

- push-pointing
- drawing
- hardening
- stretch-forming
- blanking (sizing)
- tempering
- finishing
- pickling

Some remarks to the above technological stages:

- push-pointing: preparatory to clamping;
- drawing: step-forming on to longitudinal section of the tube diameter;
- hardening: heating and quenching (in water);
- stretch-forming: straightening;
- blanking: sizing of the finished product;
- tempering: holding at the requisite temperature for strength-improving purposes;
- finishing operations:
  - door blanking,
  - casing tube welding,
  - shaping the seat of mounting plate,
  - door lock welding,
  - bottom welding,
  - preparation of arms,
  - arm fixing onto the post, etc.
- pickling: degreasing, cleaning.

List of machinery: Table 26.

Machines for lamp-post manufacturing plant

Item No.	Name
1.	Push-pointing machine
2.	Drawbench unifilar, 15 t, up to dia. 180 mm, lenght 12 m
	2.1 gang saw hand tilting
	2.2 drill press
	2.3 table with rollers, length: 12 m
	2.4 swing crane, rate: 1 ton
3.	Hardening furnace, 15 m, max. temperature 550 °C
4.	Stretching bench, 250 t, max. dia. 280 mm
5.	Large diameter gang saw with hold-drawm clamp
6.	Tempering furnace, max. temperature 200 °C, 15 m
7.	Excentric press, 250 t
	7.1 door blanking tool
8.	Plate shears, 2,000 mm
9.	Welding machine (4 nos) 400 A, with automatic feeder
10.	Band saw
11.	Gang saw with adjustable table (2 nos)
12.	Vibrating shears (5 nos), hand-operated
13.	Drill press (5 nos)
14.	Milling machine
15.	Drill press
16.	Edge bending machines, 1,000 mm, with hand lever
17.	Pickling bath (4 nos), length: 14 m, width: 0,8 m, depth: 1.5 m with exhauster
	17.1 travelling crab type DEMAG
18.	Truck
19.	2 off cranes.

If the above list is completed with a 30 t drawing bench for tubes of 280 mm diameter, low- and middle voltage (20 kV) lamp-posts can also be produced in the plant.

Price of machines and equipment:	US$	2,900,000.-
Cost of design and engineering:	US$	180,000,-
Cost of know-how:	US$	100,000.-

8. Plant to manufacture aluminium overhead (aerial) cables and low-frequency insulated cables

Sequence of the manufacturing technology: wire-drawing, heat treatment, stranding, insulation and packaging.

Two types of uninsulated overhead (aerial) cables are recommended for manufacturing:

- Alloyed aluminium overhead cable as per quality of Aldrey's and Almelec's cables.
- Alumoweld type overhead cable.

The above cables have good market all over the world; they can be properly used as high-frequency cables.

Minimal installed capacity of the plant: 6,000 t/year.

Base material: cast-rolled rough wire of 10 to 14 mm diameter. For Alumoweld type overhead cable additional steel wire (abt. 25 % in weight) coated with aluminium layer is required (e.g.: the wire produced by Copperweld Steel Int. Co.).

Main machinery:

- 3 collecting and slipping type drawing lines
- 1 heat treating furnace
- 1 stranding machine
- 4 strand-welding machines

Price of main machinery: US$ 600,000.-

Additional equipment for manufacturing low-frequency insulated cables:

- 2 extruders for plastics
- 1 stranding machine

Price of the above additional equipment: US$ 320,000.-

Productive manpower requirement for manufacturing overhead cable:

8 skilled workers/shift
8 semi-skilled and unskilled workers/shift
4 workers for presetting and maintenance

20 workers/shift

Additional 12 persons are required for manufacturing insulated cables.

Cost of buildings and infrastructure depends on the location of the plant.

9. Plant to manufacture aluminium rain gutters of supported and hanging forms

Rain gutters and their accessories such as shapes, fall tubes and clamps can be produced in the plant.

Capacity of the plant: 800,000 m of gutter/year
Material requirement: 800 t.p.y. rolled aluminium strip
Price of main machinery: US$ 940,000.-
Area requirement of the plant: 500 m^2
Manpower requirement: 34 persons/shift

10. Fitter's shop to manufacture aluminium ladders, scaffolds and furniture skeletons

Equipment requirement of the shop, fulfilling demands by proper adaptability, will be minimal.

Material requirement (i.e. the processing capacity of the shop) 800 t/year.

Price of small machines and equipment: US$ 50,000.-
The required area of the shop: 300 m^2
Productive manpower requirement:
18 skilled workers
20 semi-skilled and unskilled workers

38 workers

11. Fitter's shop to manufacture aluminium inner roomforming elements, facades, portal frames and pavilons

Few general-purpose machinery such as cutting machines, welding apparatus, eccentric presses, etc. are required in the shop as in shops where special products are constructed.

Proposed capacity of the shop: 250,000 m^2/year surface
Material requirement: 1,000 t/year
Cost of machinery: US$ 95,000.-
Productive manpower requirement: 43 persons
The required area of the shop: 1,000 m^2

12. Plant to manufacture containers, tanks and bunkers

Containers, tanks and bunkers of diameter ranging from 1.4 to 2.6 m and of volume ranging from 3 to 41 m^3 can be produced in the plant for the food and chemical industries.

Capacity of the plant: 36,000 m^3/year
Material requirement: 1,200 t/year aluminium plate
400 t/year carbon steel

Price of main machinery depends on capacity.

The required area of the plant with service crane: 4,000 m^2

Manpower requirement: 120 persons (fitter, welder, painter and unskilled worker)

13. Plant to manufacture aluminium corrugated sheets

Proposed capacity of the plant: 400,000 m^2/year

Basic material requirement: 1,400 t strip of 0,8 to 1.2 mm thickness and of 1,500 mm width (roll weight: max. 8 t)

The corrugating line includes hydraulic roll-lifting device as well as machines for unrolling, pattern making, shaping, cutting and depositing.

Price of manufacturing line: US$ 1,200,000.-

Price of first tooling as per types: US$ 95,000.-

Tooling requirements can be fully satisfied by four different types.

Electric power:

- built into machines 75 kW
- for other purposes 15 kW

Cooling water: 2,400 lit/h

Compressed air: 100 lit/h

Area requirement of the plant:

- covered hall with crane 800 m^2
- storage (for rolls) 400 m^2

Finished goods can be stored packed in open air.

Manpower requirement: 4 skilled workers/shift
6 unskilled workers/shift.

14. Plant to manufacture sandwich panels for the building industries

There are two possibilities for locating the plant: connected to the sheet-manufacturing plant or separated from it.

Proposed capacity of the plant: 200,000 m^2/year

Material requirement: 1,400 t aluminium corrugated sheet
320 t polyurethane

Manufacturing technology: surface treatment, frame producing, cutting, cleaning, packaging.

List of machinery:

1 pc	surface preparing machine
1 pc	sheet turning machine
1 pc	foam producing machine
6 pcs	holding frames
1 pc	drawing device
6 pcs	rolling tables
1 pc	cutting-off saw
1 pc	froam-storage

Price of machinery: US$ 650,000.-

Required area of the plant:

for machines	1,200 m^2
for foam-storage	100 m^2

Electric power:

built into machines:	110 kW
other:	20 kW

Compressed air: 1,840 lit/h

There is no tooling cost.

Manpower requirement: 2 skilled workers
10 semi-skilled und unskilled workers.

B. Summary of the minimal capacities of the suggested factories, raw materials, power and water consumptions, staff requirements, estimated investments and operation costs

Table 27.

The minimal output figures of different products

Para	Name of the product	Unit	Quantity per year
V. A 1	Household utensils	1,000 pcs	370
2	Milk-cans	1,000 pcs	25
3	Gas cylinders	1,000 pcs	250
4	Beer casks (barrels)	1,000 pcs	40
5	Soda-water syphons	1,000 pcs	500
6	Radiators	1,000 m^2	200
7	Lamp-posts	1,000 pcs	20
8	Cables	1,000 t	6
9	Rain gutters	1,000 m	800
10	Ladders, scaffolds and furniture skeletons	1,000 t	800
11	Facades, portal frames, etc.	1,000 m^2	250
12	Containers, tanks, bunkers	1,000 m^3	36
13	Corrugated sheets	1,000 m^2	400
14	Sandwich panels	1,000 m^2	100

Table 28.

The material consumption in tons

Para	Aluminium rolled products	Extruded pressed products	Castings and forgings	Steel	Synthetics (plastics)
V. A 1	103	-	2	33	-
2	180	-	45	-	-
3	1,600	250	150	-	-
4	380	-	20	-	-
5	-	350	-	1	56
6	250	500	-	-	-
7	17	1,200	3	1	4
8	400	4,000	-	100	500
9	800	-	-	-	-
10	40	750	10	10	20
11	200	750	50	10	20
12	1,200	-	-	400	-
13	1,400	-	-	-	-
14	700*	-	-	-	160
Total	6,570	7,800	280	555	760

* Includes the quantity of corrugated sheet.

The total material consumption is 14,650 tpy.

Table 29.

Required area for production in m^2

Para	Workshop area	
	with crane	without crane
V. A 1	-	950
2	-	850
3	-	3,500
4	-	1,800
5	-	2,000
6	-	1,000
7	-	1,200
8	-	7,000
9	-	500
10	-	300
11	-	1,000
12	4,000	-
13	800	400
14	-	1,200
Total area requirement	4,800 m^2	21,700 m^2

The total requirement of the producing area (excl. offices, storages, social investments) is: 26,500 m^2.

Table 30.

Power and water demands

Para	Electric power installed in the equipment kW	Other energy kW	Water-demand m^3/hour
V. A 1	325	110	3
2	325	150	4
3	1,500	1,800	15
4	900	300	6
5	800	200	10
6	300	150	5
7	600	800	8
8	4,000	180	10
9	100	5	1
10	60	10	1
11	60	10	1
12	1,200	300	3
13	75	15	1
14	110	20	2
Total	10,355	4,050	72

In the colum "Other energy" energy requirements (e.g. fuel oil, coal, gas) converted to electric energy equivalent, are indicated.

Table 31.

Manpower requirements

Para	Productive		Others	Total
	unskilled	skilled		
V. A 1	63	15	22	100
2	18	18	14	50
3	150	66	74	290
4	40	35	25	100
5	80	30	45	155
6	60	15	20	95
7	42	10	13	65
8	24	72	34	130
9	82	20	28	130
10	60	54	36	150
11	90	39	51	180
12	240	120	30	390
13	18	12	20	50
14	30	6	14	50
Total	997	512	426	1,935

Table 32.

Estimated investment costs, in 1,000 US$

Para	Price of main equipm. fco site, uncle-ared	Building construct. setting + siting machinery	Tooling, know-how start-up of the plant	Infra-structure, etc.	Total
V. A 1	412	308	218	22	960
2	970	286	180	19	1,455
3	4,994	1,278	840	78	7,190
4	1,183	518	380	40	2,121
5	1,660	611	790	45	3,106
6	640	287	140	22	1,089
7	2,900	557	280	27	3,764
8	1,120	279	230	17	1,646
9	940	205	160	11	1,316
10	50	72	150	7	279
11	95	231	305	22	653
12	2,400	1,240	380	100	4,120
13	1,200	409	530	29	2,168
14	650	330	80	28	1,090
Total	19,214	6,613	4,663	467	30,957

The buildings and infrastructure costs are estimated.

Table 33.

Estimated operation costs, in 1,000 US$

Para	Direct materi-als	Direct man-power	Factory over-heads	Administ. over-heads	Sales costs	Operating cost per year
V. A 1	330	140	980	25	25	1,500
2	652	80	480	15	3	1,230
3	5,875	429	2,100	80	6	8,490
4	1,190	160	955	30	5	2,340
5	1,013	226	1,100	40	11	2,390
6	2,150	133	670	22	5	2,980
7	3,423	91	400	16	10	3,940
8	12,465	230	1,400	50	5	14,150
9	2,400	184	1,000	36	20	3,640
10	2,264	241	1,000	45	20	3,570
11	2,844	266	1,100	50	20	4,280
12	3,800	590	2,400	120	5	6,915
13	4,200	75	200	15	5	4,495
14	3,212	53	100	10	5	3,380
Total						63,300

C. Suggested time schedule for the implementation

It is reasonable to start the developing process with plants, that

- require low investment, few equipment or building:
- require relatively great but unskilled work force whose training can be accomplished during normal operation;
- are suitable to quick product-changes, product-expansions or restrictions as demands require;
- require relatively small amounts of raw materials so that manufacturing could start smoothly even before own basic material sources will be available.

Consequently, the program might be started with ladders, furniture skeletons, sandwich panels, window frames, doors, portal frames, facades, building panels manufacturing plants, according to points V. A. 10 and 11. The rain gutters' plant, as it is relatively simple, might belong to this category, too.

The second category consists of plants that

- require greater investment;
- require semi-skilled work force;
- are producing goods primarily necessary for developing the country's economy

These are plants producing corrugated sheets, panels, lamp posts and columns according to points V. A. 13 and 14. Corrugated sheets can be used for roofing and cladding industrial as well as agricultural buildings (workshops, halls, warehouses, sheds, stables, corn silos) because of their inherent advantages, e.g. easy transportability, quick assembly, long life, besides being practically maintenance free. They are also suitable for manufacturing thermo-insulated building panels.

Lamp post columns are necessary for the electrification program and - last but not least - have excellent chances for exporting.

The third category is made up from plants with more complex technologies, such as gas cylinder or cable plants. Some of the gas cylinder manufacturing equipment can be used for fabrication of other hardware, milk cans, beer casks but certainly not at optimum capacities and only if the original products remain unchanged or export demands require neither start up of an independent milk can, beer cask plant, nor expansion of existing hardware production facilities.

The rest of the proposed plants is mainly export oriented; these are the syphon plant according to point V. A. 5 and the heat exchanger plant according to point V. A. 6.

The four phases of developing process shall lastly be justified by the fact that know-how owners can be asked to provide detailed cost estimates for the plants so that it may be easy for experts and decisions makers to decide on the feasibility of the plants thus saving costs for feasibility studies.

Investment and operational costs, prices estimated now are subject to change; production costs, sales revenues are changing, too, so that the break-even point should only be determined in the evaluation, decision making phase, shortly before concluding agreements for construction.

Estimated profit of the suggested finished goods' plants at full capacities would be US$ 18 million. This means a capital recovery period of 2 years on investments. Taking usually and normally longer running-in periods into account, recovery on investment can be safely estimated as 4.5 years.

VI. MANUFACTURE OF SEMIPRODUCTS

1. Proposed technologies

The basic material for aluminium semi-production is, in general, primary ingot. However, to a less, but continuously growing extent the molten aluminium coming directly from the smelter is also applied.

The mass of aluminium pigs is in general, about 10-25 kgs but in order to facilitate the handling, so called "T"-ingots, too, with the mass of max. 1,000 kgs, are cast.

The way of processing can be divided into two, large groups. These are: the cold and the hot ductile formation. The die casting represents a separate group.

The relationship between main operations and products of the semis' manufacture is represented in Fig. 2.

Over 80 % of the world's primary aluminium production is destined for semis manufactured by ductile formation; within this group the rolled and extruded products (Table 34) are dominating. Die casting products are mainly fabricated from collected scrap (secondary metal). For the pigment manufacture only operation scrap is used.

Not even in industrially developed countries all the technologies indicated in Fig. 2 can be found because it is not necessary that each country should possess manufacturing of the total product scale. Some products can be made by alternative technologies. Technology to be applied is determined, mainly, by the quantity to be produced but the choice is influenced also by an existing or planned technological base.

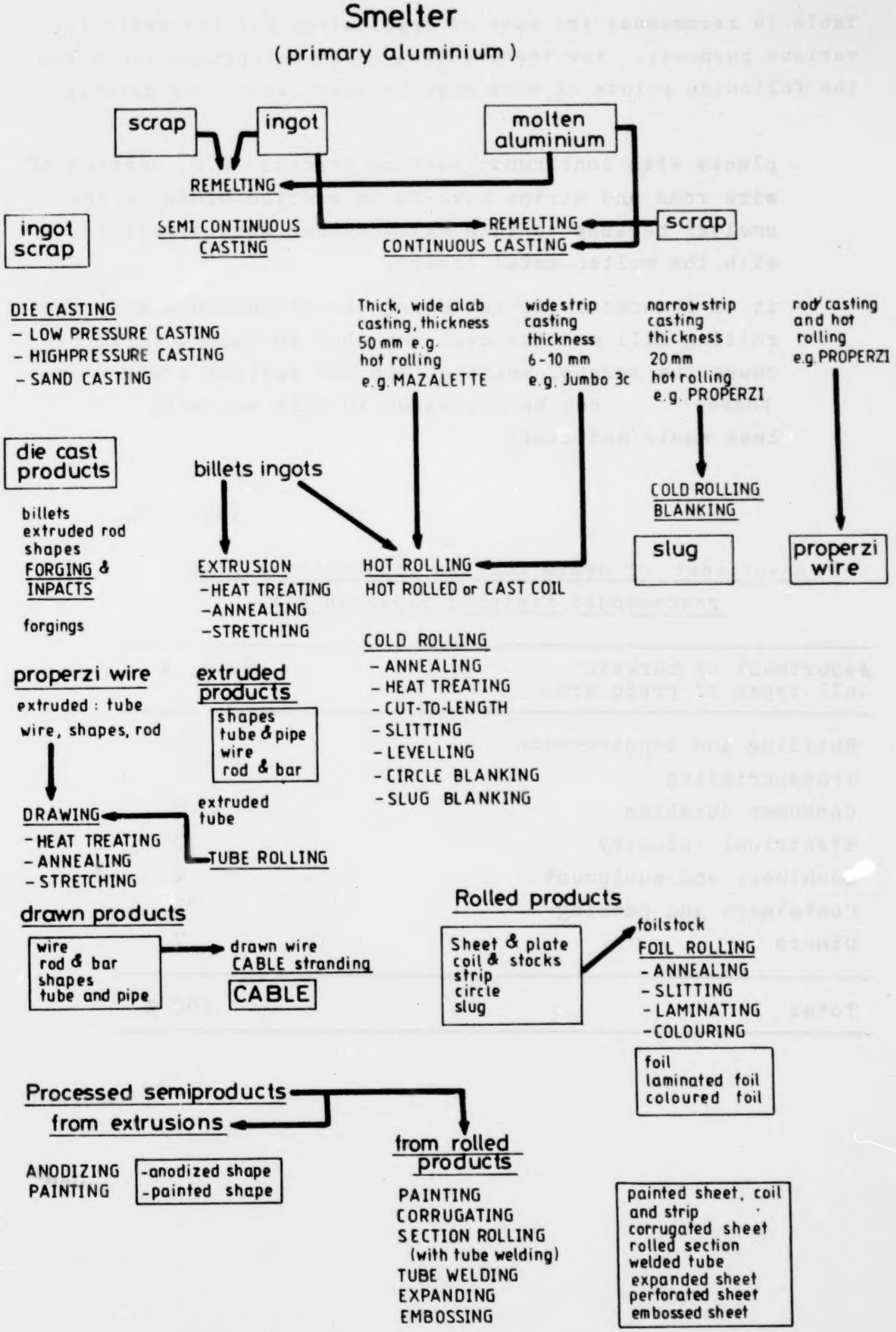
Smelter
(primary aluminium)
scrap
ingot
molten aluminium
REMELTING
ingot scrap
SEMI CONTINUOUS CASTING
REMELTING
scrap
CONTINUOUS CASTING
DIE CASTING
- LOW PRESSURE CASTING
- HIGHPRESSURE CASTING
- SAND CASTING
Thick, wide alab casting, thickness 50 mm e.g. hot rolling e.g. MAZALETTE
wide strip casting thickness 6 - 10 mm e.g. Jumbo 3c
narrowstrip casting thickness 20 mm hot rolling e.g. PROPERZI
rod casting and hot rolling e.g. PROPERZI
die cast products
billets
extruded rod
shapes
FORGING & INPACTS
forgings
billets ingots
COLD ROLLING
BLANKING
slug
properzi wire
EXTRUSION
-HEAT TREATING
-ANNEALING
-STRETCHING
HOT ROLLING
HOT ROLLED or CAST COIL
COLD ROLLING
- ANNEALING
- HEAT TREATING
- CUT-TO-LENGTH
- SLITTING
- LEVELLING
- CIRCLE BLANKING
- SLUG BLANKING
properzi wire
extruded : tube
wire, shapes, rod
extruded products
shapes
tube & pipe
wire
rod & bar
extruded tube
DRAWING
- HEAT TREATING
- ANNEALING
- STRETCHING
TUBE ROLLING
drawn products
wire
rod & bar
shapes
tube and pipe
drawn wire
CABLE stranding
CABLE
Rolled products
Sheet & plate
coil & stocks
strip
circle
slug
foilstock
FOIL ROLLING
- ANNEALING
- SLITTING
- LAMINATING
- COLOURING
foil
laminated foil
coloured foil
Processed semiproducts
from extrusions
from rolled products
ANODIZING
PAINTING
-anodized shape
-painted shape
PAINTING
CORRUGATING
SECTION ROLLING
(with tube welding)
TUBE WELDING
EXPANDING
EMBOSSING
painted sheet, coil and strip
corrugated sheet
rolled section
welded tube
expanded sheet
perforated sheet
embossed sheet

Table 34 recommends the rate of application for the semis for various purposes. For the erection of a semi-production plant the following points of view must be taken into consideration:

- plants with continuous casting process i.e. casting of wire rods and strips have to be erected close to the smelter because in this way they can work directly with the molten metal insert;
- it is reasonable to establish the extrusion plant, the rolling mill and the cast workshop in one factory, because the scraps, arising from the various production phases can be processed in this way with less waste and cost.

Table 34.

Assortment of semis for the production of the recommended finished products mix

Assortment by markets (all types of producers)	Rate, %
Building and construction	20
Transportation	25
Consumer durables	7
Electrical industry	10
Machinery and equipment	6
Containers and packing	25
Others	7
Total	100 %

Aluminium mill product mix by type of products

Product	Rate, %
Sheets and Plates, Coils, Circles, Slugs	55
Foils	7
Wires and Cables, Rods, Bars (excluding extruded products)	10
Extruded products (including rods and bars, pipes and tubes, shapes, drawn tubes)	24
All others (welded tubes, powder and paste, forging and impacts)	4
Total	100 %

1.1 Rolled products

The rolled products are: plates, sheets, shaped sheets, circles, foils, welded tubes, bended profiles and slugs.

The technologies of rolling mills differ from each other in the manufacture of the master strips with the thickness of 3-10 mm. The master product is made by the traditional and the most frequently employed technology, from ingot of 4-12 t mass with 300x500x1000-2000 mm section, by hot rolling.

The various continuous strip-casting or cast-rolling procedures are, however, more and more spreading.

The advantages of the continuous procedures are already indisputable in many fields:

- production output (recovery, yield) of the hot rolled strips is 75-80 %, that of cast-rolled is 90 %;
- for manufacture of cast-rolled strips the energy consumption is by 30-35 % less than for the hot rolled ones.

An up-to-date cast-rolling equipment has a capacity of 10-15 thousand t/y that means, the project can be realized in smaller units, too. In case of hot rolling the smallest, up-to-date and economical unit has a capacity of 100 thousand tons/y at present.

Taking into account the above mentioned facts and planned consumption of the finished products, it seems practicable to lay the basis of rolled products manufacture in the cast-rolling process.

The projected mill consists of two parts, as:

- continuous strip-casting plant with a capacity of 27,000 t/y,
- cold strip- and foil-rolling plant with a capacity of 20,000 t/y.

1.2 Foundry shop, including continuous strip casting machines (total capacity: 27,000 t/y)

By this method the strip is produced on a rotary system casting machine. The feeding with molten metal is done from a holding furnace by means of a trough and tun-dish. A contact float operating on the surface of metal feed regulates the level in the trough. The casting rolls are cooled by inner water circulation and supply a strip 6 mm to 10 mm thick.

Production program

Al 99.5 - Al 99.0	17,000 tons
AlMg, AlMn	9,000 tons
AlMg 4.5 Mn	1,000 tons

List of the main equipment and their costs (including installation cost):

	Equipment		Cost in 1,000 US$
1.	Gas melting furnaces	2 pcs	1,400.-
2.	Electrical holding and casting furnaces	2 pcs	1,200.-
3.	Continuous strip casting machines	2 pcs	7,400.-
	Total cost of the main equipments		10,000.-

	Additional equipment		Cost in 1,000 US$
4.	Feeders with rotary heads	2 pcs	320.-
5.	Trucks and cranes for handling		300.-
6.	Small machines, controlling and qualifying equipments		200.-
7.	Tool-manufacture, maintenance		300.-
8.	Hall, social and communal establishments (8000 m^2)		4,000.-
9.	Infrastructure (water, gas, steam, compressed air, electric inputs, connections)		800.-
10.	Environmental protection		300.-
	Total (4-10)		6,220.-
	Total cost of the installation		16,220.-

Energy requirements:

Electric energy	2,300	MWh/y
Gas (with a calorific value: 36 MJ/m^3)	4.8	million m^3/y
Cooling water (at least with ten-times recirculation)	1.3	billion m^3/y
Compressed air (6 bar)	6	billion m^3/y

Manpower requirement:

Metallurgical engineer	2 persons
Other engineers	2 persons
Technician (metallurgical, mechanical, electrical)	11 persons
Skilled worker	35 persons
Unskilled worker	60 persons
Total	110 persons

1.3 Continuously cast and cold rolled products

Table 35.

Continuous casting shop and cold rolling mill for production of rolled goods

(Total capacity: 20,000 t.p.y. of rolled products mix)

Product/utilization	Quantity tons		Rate %
Sheets and Plates			50
Building (sheets for anodizing)	2,000		10
Building (lacquered sheets, flat or shaped)	4,600		23
Van sheets, coach and waggon sheets	800		4
Consumer durables	800		4
Machinery and equipment	1,000		5
Litho sheet	-		1
Corrugated sheet, embossed sheet	-		3
Coils		6,600	33
Foil stock	3,600		18
Fin stock	600		3
Lacquered (varnished) foil for food packing	800		4
Closure stock, can body stock	600		3
For welded tubes, profiles	1,000		5
Circles		2,800	14
Kitchen utensils	2,000		10
Deep-drawn containers	800		4
Slugs		300	3
Total (including foil-stock)	20,000		100
Total (without foil-stock)	16,400		
Foil	3,000		

Table 36.

Cold rolling mill including foil rolling

(Total capacity: 20,000 t.p.y.)

List of the main equipment

Equipment	Quantity and specification		Capacity t.p.y.
1. Cold rolling			
Cold mill	1 pc	4-High non-reversing mill 500/1200x1800 mm 2000 kW, 600 m/min., max. 10 tons coils	20,000*
2. Annealing			28,000
Annealing furnaces	2 pcs	Electric heated atmosphere controlled 25 tons/charge	
3. Slitting			15,000
2500 mm line	1 pc	200 m/min, 10 tons/coils	
500 mm line	2 pcs	200 m/min, 3 tons/coils	
4. Cut-to-length			8,000
1500 mm line	1 pc	90 m/min	
5. Tension levelling			8,000
1500 mm tension leveller	1 pc	100 m/min	
6. Circle (disc) blanking			3,000
Continuous circle blanking lines	2 pcs		
7. Foil rolling			3,000
Foil mill	1 pc	4-High non-reversing mill 200/800x1500 mm 300 kW, 800 m/min, max. 3 tons coils	
8. Foil finishing and heat-treating			3,000
(slitters, pointers, mounting lines)			

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* Including 3,000 tons foil stock and foil prerolling.

Table 37.

Costs of the rolling mill

	Equipment		1,000 US$
1.	Cold mill	1 pc	17,000
2.	Annealing furnaces	2 pcs	3,300
3.	Slitting lines	2 pcs	2,000
4.	Cut-to-length line	1 pc	2,000
5.	Tension leveller	1 pc	4,200
6.	Circle blanking lines	2 pcs	700
7.	Foil rolling mill	1 pc	4,000
8.	Foil slitting, pointing, mounting lines	2 pcs	11,000
	Total cost of the main equipments		44,200
9.	Roll-grinder and tool-manufacture (building, installation)		1,100
10.	Repair shop for electric and machinery equipment (building, installation)		3,100
11.	Material testing, quality control		500
12.	Energy supply system		2,000
13.	Communication		300
14.	Workshop with social and communal installations		19,500
	Total (9-14)		26,500
	Total investment costs		70,700

Energy requirements:

Electric energy	15,500 MWh/year
Gas (calorific value: 36 MJ/m^3)	1.5 million m^3/year
Cooling water (recirculated)	0.7 billion m^3/year
Compressed air (6 bar)	5.5 billion m^3/year

Manpower requirement:

Metallurgical engineers	2 persons
Mechanical engineers	3 persons
Electrical engineers	1 person
Technician	10 persons
Skilled workers	85 persons
Unskilled workers	90 persons
Total	201 persons

1.4 Extruded and drawn products

Extrusion billets are homogenized, then preheated in the extrusion shop to the proper extrusion temperature.

The extrusion lines are built together with the complete finishing equipment (quenching, stretcher, saw), giving completely worked, cut, straightened products.

The products will then be cold-rolled into tubes and rods with consecutive quenching and annealing.

Table 38.

Expected break-down of extruded and drawn product mix

Product	Quantity t.p.y.		Rate %	
Shapes		7,800		52
Building and structural industries	6,750		45	
Vehicles, traffic industries	300		2	
Consumer durables industries	450		3	
Engineering shapes industries	150		1	
Others	150		1	
Rods and rails		600		4
Press forging semis	300		2	
Engineering uses	150		1	
Others	150		1	
Wires and rods		4,950		33
Extruded tubes		1,350		9
Building	750		5	
Agriculture	300		2	
Vehicles, traffic	150		1	
Infrastructure purposes	150		1	
Drawn tubes and rods		300		2
Consumer durables	150		1	
Others	150		1	
Total		15,000		100

Table 39.

Expected break-down of alloys used in the extrusion and drawing shop

Alloying rate	Uses	Rate %
Unalloyed	Shapes, semis for cable and wire production, extruded tubes	25
Low-alloyed	Shapes, semis for cable and wire production, rods and rails, extruded tubes, drawn rods and tubes	65
Highly alloyed	Rods and rails, extruded tubes, drawn rods and tubes, semis for wires' production	10

Table 40.

List of equipment for a 15,000 t.p.y. capacity extrusion and drawing plant

Equipment		Quantity and characteristics		Capacity t.p.y.
1. Extrusion line with billet heating furnace, finishing equipment and tool-heating furnace				
Presses:	35 MN	1 pc	with flat recipients	4,000
	25 MN	2 pcs	rod press, Ø 200 mm and 250 mm billets	6,000
	16 MN	1 pc	rod press, Ø 150 mm and 200 mm billets	1,800
		1 pc	tube press, Ø 150 mm and 200 mm billets	1,800
	12 MN	1 pc	Ø 150 mm billets	1,400
2. Annealing furnaces		3 pcs	moving hearth furnace, gas heated	8,000
3. Quench furnace		2 pcs	vertical, electric heated	3,000
4. Shape rolling machine		2 pcs	for max. 100 mm shapes	-
5. Tube and rod stretcher		1 pc	for max. Ø 120x8000 mm product	3,000
6. Press straightener		1 pc	for max. Ø 50x8000 mm product	1,000
7. Press straightener		1 pc	hydraulic press	2,000
8. Tube and rod drawing machine		1 pc	with 100 kN rated force	1,200
		1 pc	with 50 kN rated force	800
9. Tapering machines		-	-	-
10. Others (finishing, packing machines)		-	-	-
11. Transport and handling equipment		-	-	-

Table 41.

Costs of a 15,000 t.p.y. capacity extrusion and drawing plant

Equipment	Pcs	Price, 1,000 US$
1. Extrusion lines with billet heating furnace, finishing equipment, tool heating furnace, complete	6	17,000
2. Annealing furnaces	3	1,300
3. Quenching furnaces	2	900
4. Shape rolling machines	2	300
5. Tube and rod stretchers	2	460
6. Press straightener	1	60
7. Tube and rod drawing machines	2	710
8. Tapering machines		140
9. Others (finishing, packing machines)		300
10. Transport and handling equipment		1,000
Auxiliary facilities		
1. Tooling, maintenance (building and equipment)		2,000
2. Electricals and machine shops (building and equipment)		1,500
3. Material testing, quality control		400
4. Power distribution system		1,300
5. Communication system		200
Production building with social and communal facilities		14,300
	Total:	41,870

Energy requirements:

Electric energy	12,600 MWh/year
Gas (calorific value: 36 MJ/m^3)	2,500 m^3/year
Cooling water (recirculated)	1.5 billion m^3/year
Compressed air (6 bar)	4 billion m^3/year

Manpower requirement:

Metallurgical engineers	2 persons
Mechanical engineers	2 persons
Electrical engineer	1 person
Technicians	12 persons
Skilled workers	85 persons
Unskilled workers	88 persons
Total	190 persons

1.5 25,000 t.p.y. extrusion billet casting shop

Capacity of the connected extrusion plant: 15,000 t/y. The casting shop produces in 65 % low-alloyed, 25 % unalloyed and 10 % highly alloyed billets.

Sizes of billets vary from Ø 150 mm to Ø 350 mm, mostly in the size range of Ø 200 mm.

60-70 % of the billets leave the casting shop as threads, the remaining 40-30 % will be cut to length.

The highly alloyed billets are scalped.

Production of the billet quantity needed will be made in 5 duplex melting-casting units. Holding capacity of the melting furnaces is 26 t each, of the casting furnace 20 t each, while loadibility of the casting machines is 20 t each.

Table 42.

Equipment and investment costs of a 25,000 t.p.y. semi-continuous billet casting shop

(Main machinery including erection costs)

Name	Pcs	Cost 1,000 US$
Semi continuous billet-casting equipment with duplex furnaces (26/20 t), purifying salt jets, launder preheating and continuous refining equipment	2	9,500
Homogenizing furnace	1	2,400
Saw	1	650
Billet scalping unit	1	100
Tool preheating furnace	1	180
Rotary charging devices	2	300
Transporting and handling equipment (cranes, trucks)		500
Others (labour saving devices, control and qualifying equipment)		300
Tooling, maintenance shop		680
Building, social and communal facilities		4,500
Utilities (water, gas, nitrogen, compressed air, environment protection equipment, chimney stacks, ducts)		2,100
Total		21,110

Energy requirements:

Electric energy	2,800 MWh/year
Gas (36 MJ/m^3 calorific value)	5 million m^3/year
Cooling water (min. 10-times recycled)	1.1 billion m^3/year
Compressed air (6 bar)	2.2 billion m^3/year

Manpower requirement:

Metallurgical engineers	2 persons
Mechanical engineers	2 persons
Technicians	10 persons
Skilled workers	30 persons
Unskilled workers	50 persons
Total	94 persons

1.6 Manufacture of starting material for wire- and cable production

The master product of drawing mills, the preliminary wire-rod can be made in two ways : by extrusion and by continuously casting-hot-rolling procedure.

The smallest nominal capacity of one press which can be established for extrusion, is some thousands of tons of extrusions but if the same press is used for wire rods production, only a much smaller quantity can be manufactured, thus actual capacity for wire production below 1,000 tons should not be envisaged.

At the continuous casting-rolling procedures the capacity of one equipment is already up to 30,000 tons per year at present, but the machines which were built 15 - 20 years ago have a capacity of only 5 - 15,000 tons per year.

The biggest equipment supplyers are as follows: Properzi, Secim, Southwire, A.Mann.

Continuous casting-rolling mill for wires and rods

(Capacity: 20,000 t.p.y.)

The plant is working with liquid charge.

The material qualities which can be used, are:

EAl 99.5 (electrical)
EAlMgSi (electrical)

The wire-diameters which can be produced:		7.5-12	mm.
Sizes of coils:	external diameter	2.000	mm
	height	2.000	mm
	weight, max.	2	tons

Table 43.

Parameters of the equipment and the investment costs of a 20,000 t.p.y. casting-rolling mill

(including the costs of erection)

Name and capacity	Costs, 1,000 US$
1. 2 pcs equalizing furnaces, tiltable	1,500
2. Continuous metal refiner, with Cl_2-N_2 gas mix, with two rotary heads	750
3. Continuous casting-rolling machine with reeling device of capacity 5.5-7.5 tons per hour with auxiliary equipment	6,191
4. Tool-preheating furnace	80
5. Transporting and material handling equipment	200
6. Other equipment, small machines, controlling devices	100
7. Tool manufacture, maintenance	200
8. Workshops, social and communal establishments	850
9. Civil works incl. environmental protection	1,200
Total	10,621

Energy requirements:

Electric energy	2,340 MWh/year
Gas (calorific value: 35 MJ/m^3)	2 million m^3/year
Water (recirculated)	1.1 billion m^3/year
Compressed air (6 bars)	1.5 billion m^3/year

Manpower requirements:

Metallurgical engineer	1 person
Other engineers	2 persons
Technicians	7 persons
Skilled workers	30 persons
Unskilled workers	50 persons
Total	90 persons

1.7 Production of forgings

Forgings can be produced either from cast billets or from extruded bars of circular, square or multiangular cross-sections.

Break-down of the starting materials:

extruded bars	95 %
cast billets	5 %

Suggested product mix:
for the following fields:

- buildings
- vehicles
- transports
- consumer durables
- engineering (parts, assemblies)
- other miscellaneous usage.

Table 44.

Investment of a 1,000 t.p.y. press-forging shop

(Capacity in 3 shifts: 1,500 t.p.y.)

Equipment	Pcs	Costs (incl.foundation are erecting) 1,000 US$
1. a/ 400 t friction press b/ preheating chamber-furnace, with resistance heating, 2x60 kW	1	1,000
2. a/ 800 t friction press b/ preheating chamber-furnace, with resistance heating, 2x80 kW	1	1,600
3. a/ 1,200 t friction press b/ preheating chamber-furnace, with resistance heating, 2x100 kW	1	2,900
4. Tool preheating chamber-furnace, with resistance heating for the presses under 1 and 2	1	50
5. Semis cutting semi automatic saw for: Ø 10- 90 mm Ø 60-120 mm	2	450
6. Trimming press 63 t 100 t	2 1	100
7. Quenching, ageing furnace with air circulation, resistance heating	4	550
8. Pickling equipment	1	420
9. Material handling equipment (overhead cranes, trucks)	-	300
10. Building with utilities and energy distribution (water, gas, electricity and social facilities)	-	2,550
Other miscellaneous equipment	-	550
Total		9,470

1.8 Remelting facilities

Remelting of materials will be made usually in three cases:

- remelting of virgin aluminium ingots,
- remelting of classified quality scrap of the semis' shops,
- remelting of scrap coming from outside sources, such as disassembled equipment or gleaning.

Remelting of virgin aluminium can take place in a foundry connected to the extrusion shop. This can be avoided only when foundries are built together with or in the neighborhood of the smelter. This solution would cause another problem, i.e. extrusion, and rolled scraps should be transported to the smelter which again increases transporting costs.

Apart from electrotechnical use, classified scrap of semis' shops is equal in quality to those of virgin aluminium, in some cases their application in the charge is even advantageous e.g. for alloys containing magnesium. When remelting shop scraps, foils and chips are to be handled separately; the latter have to be compacted before melting.

If scrap coming from outside sources is remelted, 2,000 t.p.y. capacity proves to be economical for building new remelting facilities. Small moulding shops may utilize gleaned scrap directly. Ingot casting shops can also utilize scrap after double remelting and in a maximum quantity of 1,000 t.

Table 45.

Investment costs of a 2,000 t.p.y. remelting facility

(No separate building was considered, it can be placed into the extrusion billet foundry)

	Equipment	Investment costs, 1,000 US$
1.	Scrap compacting equipment	25
2.	Scrap remelting furnace, 3 t	140
	Total	165

VII. SOURCES OF KNOW-HOW AND TECHNOLOGY

To accelerate self-development, the following foreign services are available:

- import of know-how
- plus import of equipment
- plus import of a turn-key plant.

Buying a technology proved by a plant scale operation, is 100-times higher in price than the price of only the written know-how. In general, the import of know-how comprises the following services:

- supply of technology and technical descriptions,
- operation- and maintenance-instructions,
- testing- and qualification-prescriptions,
- models and prototypes,
- transfer of experience,
- planning of plant organization,
- training of personnel,
- supervisions,
- commissioning,
- consultancy,
- continuous technical- and management-assistance.

Plant-import means the complex supply of equipment and installations. The project can be also implemented by a prime contracting organization as a turnkey plant establishment.

A higher stage is to conclude a long-term agreement in the frame of a joint venture.

The price of know-how is generally 3 to 10 % of the value of the plant established, depending on the supplier's participation in the realization.

In addition to this expenses, charges for Project Area Services of the Seller's employees as well as their accomodation and travelling costs and daily subsistence allowances are to be paid.

Daily subsistence allowances range from 30 to 70 $ and are paid to the employees on site.

Some sources of know-how concerning various products and finished goods are shown in Table 46.

Table 46.

Sources of know-how of semis and finished aluminium goods manufacture

Product/technology	Source
Continuous casting	Alcan Research and Development Ltd., Canada
	Vereinigte Aluminiumwerke A.G., P.O.Box 100440 40480 Grevenbroich 1, FRG
	ALUSUISSE Feldeggstrasse 4 CH-8034, Zurich, Switzerland
	National Southwire Company (NSC) Fertilla Street, P.O.Box 1000, Carrolton, Georgia 30117, USA
Aluminium casting, die casting	Mitsubishi Light Metal Ind. Copr., Japan
	Toshiba Machinery Corp., Japan
	Kaiser Aluminum and Chemical Corp. 300 Lakeside Drive, Oakland (Ca) 94643, USA
Separation of aluminium from scrap	R.Fischer, FRG
	VEB Mansfeld-Kombinat Wilhelm Pieck, Freiberg, GDR

cont'd

Product/technology	Source
Recycling aluminium scrap	Vereinigte Aluminium Werke A.G. D-5300 Bonn, FRG
Aluminium extraction from scrap	Sharkey Metals Ltd., UK
Permanent mould castings	Fuso Light Alloys Co. Ltd., Japan
Low pressure die-casting	Reynolds Metals Co. One Union National Place Little Rock, Arkansas 72201, USA
Melting furnace design	Outokumpu Oy P.O.Box 27, SF-022201 Espo 20, Finland
Castable aluminium alloys	Nippon Light Metal Research Lab. Ltd. 7-3-5 Ginza, Chuoko, Tokyo, Japan
Wire drawing	Fujikura Cable Works Ltd., Japan
	ALUSUISSE Feldeggstrasse 4 CH-8043, Zurich, Switzerland
	National Southwire Co. Fertilla Street, P.O.Box 1000, Carrolton, Georgia 30117, USA
	Nippon Light Metal Research Lab. Ltd. 7-3-5 Ginza, Chuoko, Tokyo, Japan
Cold rolling	Sumitomo Metal Industries Ltd. Tokyo, Japan
	Norsk Hydro, Norway
Extrusion	Sumitomo Light Metal Ind.Ltd. Tokyo, Japan

cont'd

Product/technology	Source
Welding	ALCOA International Inc. Av.d'ouchy, CH-1006 Lousanne, Switzerland
Electric coloring, anodizing	Pechiney Ugine Kuhlmann, France
	Sumitomo Aluminium Corp., Japan
	ALCAN Research and Development Lab., Canada
	Nippon Light Metal Research Lab. Ltd. 7-3-5 Ginza, Chuoko, Tokyo, Japan
Building structures	ALUTERV-FKI Hungalu Engineering and Development Centre H-1133 Budapest, Pozsonyi ut 56. Hungary
Deep-Freezing storage houses	ALUSUISSE Feldeggstrasse 4, CH-8034 Zurich, Switzerland
	Energy Management Institute (EGI) H-1027 Budapest, Bem rakpart 33-34. Hungary
Doors and windows	Factory of Metal Works (Fémmunkás Vállalat) H-1394 Budapest, P.O.B. 380 Hungary
Container-type elements	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary
Hothouses (greenhouses)	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary
Automotive wheels	ALUSUISSE Feldeggstrasse 4, CH-8034 Zurich, Switzerland

cont'd

Product/technology	Source
Automotive wheels	Ardal Og Sunndal Verk A.S. P.O.Box 2469 Solli, N-Oso 2, Norway
Aluminium truck frames	Reynolds Metals Co. One Union National Place Little Rock, Arkansas 72201, USA
Cooking utensils	Aluminium Ware Factory H-1142 Budapest, Erzsébet királyné utja 57-61. Hungary
Soda-water siphons, beer barrels, radiators	"Lehel" Refrigerator Works H-5101 Jászberény, P.O.Box 64, Hungary
Heat exhangers, radiators	"Lehel" Refrigerator Works H-5101 Jászberény, P.O.Box 64. Hungary
Sea-water desalting Installations	Societe Egico, Paris, France Energy Management Institute (EGI) H-1027 Budapest, Bem rakpart 33-34, Hungary
Mine props	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary
Aluminium alloy conductor wire	ALUSUISSE Feldeggstrasse 4, CH-8034 Zurich, Switzerland Sumitomo Electric Industries Ltd., Japan
Raw material of aerial condustors and cables	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary

cont'd

Product/technology	Source
Raw material of aerial conductors and cables	Research Institute of Electrical Engineering (VEIKI) H-1168 Budapest, P.O.B. 233. Hungary
Cables stranded from alumoweld wires	Vereinigte Metallwerke Ranshofen-Berndorf Uraniastrasse 2, A-1010 Wien, Austria
Stranded cables	Hungarian Cable Works (MKM) H-1117 Budapest, Budafoki ut 60. Hungary
Insulated conductors and cables	Hungarian Cable Works (MKM) H-1117 Budapest, Budafoki ut 60. Hungary ALCAN Ltd. Dufourstrasse 43. Zurich Switzerland
Electric assembly units	Allgemeine Elektrizitätsgesellschaft (AEG) Bebelstrasse 24. D-7 Stuttgart FRG Electric Equipment and Apparatus Works (VBKM-EKA) H-1457 Budapest, Füzér u. 37-39. Hungary
Telecommunication cables	Southwire Company Fertilla Street P.O.B. 1000, Carrollton, Georgia 30117, USA
Electric busbars, cable channels	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary Székesfehérvár Light Metal Works H-8001 Székesfehérvár, Adonyi u.64. Hungary

cont'd

Product/technology	Source
Electric busbars, cable channels	Balassagyarmat Metalworking Enterprise H-2660 Balassagyarmat P.O.B.30. Hungary
	Electrical installation Enterprise (VIV) H-1400 Budapest, Sip u. 23. P.O.B. 67. Hungary
SF6 insulated switching equipment	BBC Aktiengesellschaft Brown-Bovery, Postfach 85, CH-5401 Baden, Switzerland
	Ganz Electrical Works H-1525 Budapest, Lövőház u.39. P.O.B. 63. Hungary
Transformers	Csepel Transformer Factory H-1751 Budapest, P.O.B. 72. Hungary
	Transformatoren Union, A.G. Katzwanger Strasse 150 Nürnberg, FRG
	Westinghouse Electrical Company Shargon, Pa. 16146, USA
Capacitors	Mechanical Works H-1502 Budapest, P.O.B. 64. Hungary
	GIPROCVETMET, Moscow, USSR
Lighting fixtures	Electrical Equipment and Apparatus Works VBKM-EKA H-1457 Budapest, Füzér u.37-39. Hungary
Deep-drawn light-weight containers	R.Rosch GmbH, FRG
Welded containers	VEB Transformatorenwerk, GDR

cont'd

Product/technology	Source
Collapsible tuber for toothpaste etc.	Sumitomo Aluminium Smelting Co. Ltd. 7-9-2 Chome, Nihonbashi, Chuo-ku, Tokyo, Japan
Containers with stamped base	Reynolds Metals Co. One Union National Place Little Rock, Arkansas 72201, USA
Beverage cans	Pechiney Ugine Kuhlmann, France
Gas cylinders	Aluminium Ware Factory H-1142 Budapest, Erzsébet királyné utja 57-61. Hungary
High-pressure tanks	Scanaluminium Vika Oslo, 1. P.O.B. 1857. Norway
Storage and transport cans	"April 4" Machine Works (Április 4. Gépipari Müvek) H-6100 Kiskunfélegyháza, Csáni ut 2., Hungary
Barrels, small containers, pallets	Hungarian Aluminium Corporation (HUNGALU) H-1133 Budapest, Pozsonyi ut 56. Hungary
Beer and drink boxes	Aluminium Co. of America 1501 Alcoa Building Pittsburg, Pa. 15219, USA
Cans	GEBAL, Paris 8^{e} 47 rue de Monceau France
	Karges-Hammer Maschinen GmbH Frankfurter Str. 36. Braunschweig, 330, FRG
Bottle closures	Pano-Verschluss GmbH KG Gesstrasse 29, Itzehoe, FRG

cont'd

Product/technology	Source
Collapsible tube	CEBAL, Paris 8^e 47 rue de Monceaus France CHEMIMAS H-1103 Budapest, Noszlopy ut 1. Hungary
Solar energy technology	Sumitomo Light Metal Ind. Ltd. Japan Development des Applications de l'Energie Solaire F-75016, Paris 28 rue de la Soure France Phenol Engineering S.A.R.L. Av. de Lattre de Tassigny 69 330 Meyzieu, France

Any mammoth company (Pechiney, ALCAN, ALCOA, ALUSUISSE, Reynolds, Kaiser, Montecatini) and also the Hungarian Aluminium Corporation (HUNGALU) together with ALUTERV-FKI, its engineering and development centre possess know-how concerning technologies for semi-production of different kinds, such as rolling, extrusion, extrusion press, forging, casting and special technologies for finished goods such as welding, surface treatment in the aluminium industry.

VIII. MEASURES TO PROMOTE PRODUCT DEVELOPMENT EFFECTIVENESS

A. Technical advice and research

Acquiring know-how, adaptation is practically the only condition for success which relies upon the maximal knowledge of the local conditions.

Intellectual and physical preparedness, beginning with detailed information about the new product and collecting foreign experiences, shall only be completed by local adaptation. Consequently, it is not advisable to rely on foreign experts in this matter who - although with profound knowledge in their professions - do not know the local circumstances. Decisive are knowledge of local conditions, personal connections that can only be acquired by local experts or by foreigners staying for at least 1-2 years at the site.

Contribution to the development of the aluminium industry, the increase of the aluminiumconsumption and the creation of aluminium traditons can only be achieved by a team living and working in the country.

Processing aluminium and its economic application in different fields require technological knowledge different from the traditional metal processing. An essential condition for establishing an industry is to acquire, to get acquainted with and to spread this knowledge. For this purpose, a techno-economic consulting organization is needed,

- to promote widespread economic application of aluminium,
- to introduce new application fields,

- to deepen technical aptitude for aluminium processing by consulting services, by dissemination of information by holding training courses,
- to promote cooperation between aluminium semis manufacturers and semis processing plants, analyze present and future demands and possibilities of the aluminium industry,
- to observe international progress,
- to promote adaptation and domestic development of new finished products; designing, manufacturing and testing prototypes, all these based on the collected knowledge and experience.

Financing this existing advisory service is the task of the aluminium industry; this organization conducts also developing activities facilitating thereby adaptation of foreign experience, advanced fulfilment of special home demands. It should be able to design prototypes of aluminium structures required by various industries; to assist professionals in designing these prototypes and in starting mass-production of new products.

Many countries have created their own organizations for raising the level of use of aluminium thus justifying the necessity of this kind of consulting services. These are - among others -

- in France: Centre Technique de l'Aluminium
87 Boulevard de Grenelle, F-75015 Paris
(Attached to the Pechiney concern)

- in Switzerland: Information Service of the Central
Technical Division of ALUSUISSE
Feldeggstarres 4, CH-8034, Zurich

- in Italy: Instituto Experimentale dei Metalli
Laggeri
Via G. Fauser 4, I-28100
(Attached to the Alumetal concern)

- in Austria: Vereinigte Metallwerke Ranshofen-
-Berndorf A-5282 Ranshofen-Braunau

- in GDR: Leichtmetall Technischer Beratungsdienst
Eisleben

- in Hungary: ALUTERV-FKI's Center of Aluminium Application
Budapest, Anker köz 3. fszt.
Letters: H-1389 Budapest P.O.Box 128.

- in Norway: Skanaluminium, Rosenkrantzgate 21
Vika, Oslo 1.

- in the USA: The Aluminium Association Inc.
810 Connecticut Av.
N.W. Washington, DC 20006

- in Japan: Japan Light Metal Association
Nikonbashi 2-Chome, Chou-ku Tokyo 103.

- in Australia: The Aluminium Development Council
of Australia Ltd.,
56 Pitt Str. Syney, NSW 2000

B. Marketing

In the broad sense of the word, marketing implies the formation of development and sale policies based on market research and the application of methods promoting success.

The growth of aluminium consumption, the exploration of new application fields are mainly of interest for basic material producing companies. To replace traditional structural materials by aluminium in various application fields and to maintain achievements are both technical and marketing tasks. Advisably, the advisory service should also conduct marketing activity and this activity should not be confined to common technical problems of the aluminium manufacturing and processing industry but to the following areas, too:

- evaluation of progress in the semis and finished goods production by continuous market research, data collection and processing, documentations;

- making proposals for development decisions as well as for sale of the new products;
- advertising of new products by technical booklets, promoting materials, publications;
- arranging exhibitions;
- cooperating with other technical fields, to incorporate aluminium products in standard manuals of these fields for designers, engineers;
- systematic standardization;
- co-operation with authorities of economics in the country for promotion and realization of concepts.

This last task seems to be evident. A development progress lasts for several decades and is coupled with certain risks. Not only companies but authorities of national economies in the country should participate in bearing the risk in order to form advantageous basic material structure and product assortment for the country.

Development of an aluminium industry is part of a long term economic-development strategy. Coordination between the authorities, organizations and the industry is of primary importance for the aluminium industry to maintain steady progress.

C. Standardization

Standards have to take into account the consumer's safety, integration of products, exchangeability of the pieces, environment protection, etc. When introducing a new product, it is essential that it should be evaluated by the same aspects both by manufacturers and by processing (consumers) experts.

Manufacturers and consumers of aluminium semis should agree about quality and size specifications that have to be fixed in standards. In the process of standardization, aluminium industry's experts should take part to assist solving detailed questions to assure interest of the industry. It is advisable to recognize the interests of the manufacturers, too.

Standard specifications fall in three groups:

- material standards, specifying compositions, mechanical and technological properties, sizes;
- product standards, specifying semis' properties for manufacturing purposes; finished goods' properties for users' purposes;
- technological standards specifying methods of processing.

Existing international standards and other foreign national standards might promote standardization activity. But if these are automatically accepted, they often impede progress in the beginning of developing an industry.

It is inevitable to revise foreign ones and adapt them to the country's own standards, for they can take the country's own achievements and capabilities into account.

To prepare standards and to widen standardization fields in the aluminium industry is not the task of the advisory service but of the authorities. The consulting department should, however, take the initiative. Similarly, development of the aluminium industry and of the manufacturing industry do not constitute the task of the advisory service alone, but its task is to widen the circle of those participating in the development.

Manuals and reference books are essential in influencing other industries' development engineers to participate.

To post graduate various experts in the aluminium processing industry, to develop aluminium application technics is the task of the experts working in the aluminium industry.

The best method to this is the advisory service's activity in compiling and publishing relevant materials, manuals, reference books, etc.

IX. RECOMMENDATIONS

To be able to utilize investments succesfully and quickly we suggest the following steps:

Since aluminium processing requires a technology which is different from that of the steel, the growth of attained professional knowledge is a very important factor.

The first step in the development of an aluminium processing industry is the establishment of a managing organization, economically and technologically educated which will be able to indicate the trends and conditions of the economic use of different aluminium products in the country. The professional capabilities of this managing body should be enlarged step by step to become a well informed and efficient leader organization of the industry. This managing body has to choose and train the technical and economic staff of the new plants. In order to increase the present aluminium consumption the following steps can be proposed:

- Survey of the actual aluminium consumption areas. Taking into consideration the short-term development program it can be suggested to develop those consumption areas which seem to be necessary for realization of long-term objectives, too.
- Establishing new aluminium processing plants. Knowing the available metal quantity in a certain period and the long-term developing objectives it seems useful to draw up priorities for the processing plants. It is advisable to start preparing for the production of products even before the development of a domestic semi-products manufacture, and even

in case the material to be processed has to be imported.

- The third phase is raising the technological level of aluminium processing and introducing the production of more sophisticated products. All structural materials, available in a given period, and utilizable for the production of new products must be considered. Decision on the manufacture of the products has to be made in the light of manufacturing possibilities, economic efficiency, and the home and market requirements. The purchase of the products abroad, the technology, eventually equipment, have to be taken into account during the realization of the above three phases. Purchase of know-how and co-operation with foreign experts can greatly shorten the development periods. In case of starting a new industry, which represents a great risk, it is more favourable to purchase the know-how together with the appropriate guarantees.

In the aluminium processing countries the management of the aluminium industry, the relationship between various branches of the full verticum of the production are different. But independent from the system of the organization they established their own research and development (R+D) organization including or separated from it, their technical consulting service, too.

Generally, the task of the R+D organization is to carry out laboratory tests starting from the bauxite exploitation to the finished goods' production; to create new materials; to qualify the products, to carry out physical, chemical and mechanical testing of materials to be utilized.

The task of the consulting organization is generally to train the workers for the production of finished aluminium goods, to popularize new technologies, making proposals for optimal material qualities and manufacturing methods at new products to be realized, and in general, acting as connecting link between the semis' manufacturer, the R+D organization and the finished products' manufacturers. With the help of an appropriate information-flow on technical matters it can be achieved that in a given country the general and technical knowledge on the utilization of aluminium products became a continuous one and increases gradually.

Some leaders of the aluminium industries of the developing countries have already realized this requirement and established R+D and consulting organizations for the developing of industrial branches. The necessity of an R+D organization is demonstrated by the fact that countries with a developed aluminium industry spend about 1 to 1.5 per cent of their gross return from sales of aluminium industry on research and development.

The form of consulting organization of applied techniques depends to a great extent on the situation of the aluminium industry in a given country. Irrespective of the fact that one or more primary aluminium manufacturers may be existing, the advisory organization should have an independent and neutral status. It should take into account the mutual interests of all concerned (primary manufacturers, end-consumers, semis' manufacturers, finished products' manufacturers). It is inevitably necessary to train experts working in all areas of the aluminium industry to be developed and to organize their continuous professional training. It has to be ensured that all of them working in this territory could acquire technical and economic knowledge of aluminium industries on the highest level. At the beginning it is advisable to create the consulting body for applied techniques. It can advise the central managing organizations concerning production of the most economical aluminium products, the qualities of aluminium necessary for them, and the appropriate technologies.

It has to be ensured for the leading technical and economic experts of the manufacturing plants the exchange of working experiences of production methods at foreign plants with the same profile.

As it can be read in details in the present study, the economical aluminium finished goods production cannot be reached in a country with relatively small aluminium-consumption when only the home requirements are to be satisfied. Therefore, it is not practicable to deal with the production of each kind of aluminium products. In several cases it is more economical to build up an intensive exchange of products between countries of a given geographical region. In this way it would be possible to satisfy the needs of the surrounding countries with different kind of products, and produce aluminium finished products economically.

The participation in the international distribution of labor is not only advantageous but nearly inevitable in our days and its importance will be growing further in the future. During the developing works one must try to conclude bilateral or regional co-operative agreements. The latter can be especially important from the point of view of expanding market, exchange of experience in production, possibly of common financing some investments, too.

The creation of a finished goods aluminium industry and starting of production raises first of all the question of secondary metal utilization, thereby enlarging the metal stocks. The organized recovery and recycling of aluminium scrap arising in the processing industries as well as from products which got into general use are important economic factors. It is necessary to work out a price-policy which makes the collection of scrap attractive and at the same time ensures economical advantages for the users of secondary metal.

Appendix I.

DATA REQUIRED FOR THE ELABORATION OF A DEVELOPMENT STUDY FOR ALUMINIUM INDUSTRY

1. For the running year the actual, and for the years of 1985-1990-1995-2000 the planned or supposed data that are needed are:

   a/ per capita GDP in US$ or in local currency

   b/ the population, the manpower and the average salaries (wages) of unskilled, skilled workers, technicians and engineers,

   c/ the production (output) in US$ or local currency, the investments or field assets (land, equipment, buildings, civil works), manpower (worker-employees), gross profit (before taxation) and profits of:

   - electrical industry
   - packaging industry
   - machine building industry
   - transportation and storage
   - building industry (constructions)
   - apparatus manufacture
   - household appliances production,

   d/ The consumption of the production of the listed sectors, in agriculture (irrigation, horticulture, animal husbandry, canning and cooling industry),

   e/ the import-export pattern of the above sectors.

2. The aluminium consumption in the last 4-5 years in general and in detail, according to the sectors listed in 1/c.

3. For the last 4 to 5 years, per year

   a/ the volume of export-import, with respective regions and the neighbouring countries in US$ or local currency

b/ the import of aluminium basic material and semis, the semis specified as:

- rolled products
- foils
- extrusions
- Properzi-rods and -wires
- drawn wires and cables
- castings
- forgings

in volume (tons), in value (US$), fco site

c/ the local selling prices of the specified semis, to the public sector and to private enterprises,

d/ the custom duties on the imported semis, the source of import (countries),

e/ the usual freight costs inside the country (tons/km, m^3/km) on rail, ship or trucks,

f/ the buyers' list of the detailed semis, their activity (what do they use the semis for, e.g. for production, for maintenance, etc.),

g/ the import of aluminium finished goods (e.g. cables, boxes, cans, machine parts, door and window frames, building structures, household appliances, etc.) in tons or pieces, the import prices of them fco site, the custom duties, the wholesale prices and buyers, the retail prices in some cases, h/ the average prices of some complementary materials

	Al	Fe	Cu	PVC	Wood
	$/kg				
Basic material					
sheet					
wire					
rod and shape					
tubes or pipes					

4. Data regarding the existing aluminium finished goods producers (cooking utensils, window-frame, cable-producers)

a/ name and address of these factories

b/ their production in the previous year in tons or pieces or meters, etc.

c/ their detailed material consumption (Al, iron, steel, plastics, etc.)

d/ the utilities they use for the production (electric power, water, fuel oil or coke, gas, etc.)

e/ number of employee's direct manpower (skilled, unskilled, technicians, engineers),

f/ their direct material costs, direct manpower costs, other input costs, factory overhead costs (or factory costs altogether if details are not available), administrative overhead costs, sales and distribution costs

g/ their production costs (operating costs, depreciation, interest of financial overhead costs)

h/ their sales revenue (gross profit before taxation, net profit)

i/ their fixed assets, such as land, equipment, buildings and civil work installations

j/ their main equipment (a list consisting of the type, the age, etc.)

5. The present utility prices, their expected changes until the year 2000 (in 5 year intervals),
   - electric power
   - water (industrial and cleaned)
   - fuel oil
   - coke
   - gas, etc.

6. The present construction industry (building prices with erection) in $/m^2 and $/m^3, the expected changes until the year of 2000, of
   - open sided (storages of agricultural buildings),
   - uninsulated workshops with or without cranes,
   - insulated workshops and offices with or without air-conditioning,
   - cooling houses,
   - civil works (roads, canalization, etc.).

7. What is the average rate of return on new investments in general, what are requirements on behalf of semi-product plants and finished goods producing plants, what are the expected changes until the year 2000? For the development of the aluminium industry is foreign loan contemplated? If so, to what extent?

   What are the prevailing interest rates in the public sector and in the private sector in case of
   - short term loans,
   - long term loans

   and what are the expected changes until the year 2000?

What depreciation rules and laws are in force in the country and what are the expected changes until the year 2000?

8. Which government organization supervises the existing development organization?

   Which organizations are supervised by the existing development organization?

   Which are the responsibilities and rights of the existing development organization?

   Are there any plans of increasing and enlarging the organization and changing its rights and responsibilities?

   Are there any valid agreements or planned agreements with foreign partners in the field of the development of the aluminium industry?

Appendix II.

THE MOST IMPORTANT PLANTS OF SEMIS IN EUROPE

Country	Firm	Capacity	
Austria	Ranshofen	100	Rolled, extruded
Belgium	Alcan	11	Extruded
	Sidal	230	Rolled, extruded
Denmark	ASV	17	Extruded
		8	Foil
Finland	Nokia	30	Extruded, wire
France	Pechiney	400	Rolled
		60	Extruded
	Forges	42	Rolled
	Alcan de France	26,5	Extruded, powder
	Alusuisse France	15,5	Extruded
	Cuivre et Alliages	15	Extruded
	SCAL	50	Foil
FRG	Alcan, Germany	80	Rolled
	Alusingen	225	Rolled, extruded
	Kaiser	75	Rolled, extruded
	Felten and G.	25	Wire
	VAW	200	Rolled, extruded
	Norf	500	Rolled
	Reynolds	60	Rolled
		20	Extruded
	Wieland Werke	20	Extruded
Greece	Viohalco	50	Rolled, extruded, foil
Italy	Alluminio	38,5	Rolled, extruded
	Alcan, Italy	55	Rolled, extruded
	SLIM	81	Rolled, extruded

Italy	SAVA	90	Rolled
		30	Extruded
		5	Wire
		10	Foil
	Metra	15	Extruded
Netherland	Alcoa	45	Rolled, extruded
	Reynolds	24	Extruded
	Nedal	10	Extruded
Norway	Nork Hydro	60	Rolled, extruded
	Nordisk Aluminium	40	Rolled
Portugal	Portalex	14	Extruded
	Quintas	18	Wire
Spain	Inasa	70	Rolled, extruded
	Endasa	100	Rolled, extruded
	Alugasa	80	Rolled, extruded
	Alu-Perfil	15	Extruded
	Secem	15	Cable
Sweden	SAPA	30	Extruded
	Granges	85	Rolled, extruded, wire
	AG Elektrokoppar	57	Wire
Switzerland	Alusuisse	95	Rolled, extruded
	Al.Ag.Menziken	20	Rolled, extruded
	A. Rorschach	25	Rolled, foil
	A. Press	18	Extruded
	R.V. Neher	13	Foil
Great-Britain	Alcan	275	Rolled, extruded
	Alcoa G.B.	50	Rolled
	BACO	170	Rolled, extruded
	BICC Metals	12,5	Extruded, wire
	Star (Alusuisse)	55	Rolled, foil
Hungary	HUNGALU	200	Rolled, extruded, wire

Appendix III.

LIST OF STANDARDS, RECOMMENDATIONS AND TECHNICAL REPORTS OF THE ISO

(International Organization for Standardization)

ISO/R	115-1986	Classification and composition of unalloyed aluminium ingots for remelting
ISO/	121-1980	Magnesium-aluminium-zinc alloy ingots and alloy castings - Chemical compositions and mechanical properties of sand cast reference test bars
ISO/R	164-1960	Composition of aluminium alloy castings
ISO/R	208-1961	Composition of aluminium alloy castings
ISO/R	209-1971	Composition of wrought products of aluminium and aluminium alloys - Chemical composition (per cent)
ISO/R	388-1964	ISO metric series for basic thicknesses of sheet and diameter of wire
ISO/R	503-1966	Composition of wrought magnesium-aluminium-zinc alloys
ISO/	793-1973	Aluminium and aluminium alloys - Determination of iron - Orthophenanthroline photometric method
ISO/	795-1976	Aluminium and aluminium alloys - Determination of copper content - Oxalyldihydrazide photometric method
ISO/	796-1973	Aluminium and aluminium alloys - Determination of copper - Electrolytic method

ISO/	797-1973	Aluminium and aluminium alloys - Determination of silicon - Gravimetric method
ISO/	808-1973	Aluminium and aluminium alloys - Determination of silicon - Spectrophotometric method with the reduced silicomolybdic complex
ISO/R	827-1968	Mechanical property limits for extruded products of aluminium and aluminium alloys
ISO/R	838-1968	Mechanical property limits for rivet stock of aluminium and aluminium alloys
ISO/R	829-1968	Mechanical property limit for aluminium alloy forgings
ISO/	886-1973	Aluminium and aluminium alloys - Determination of manganese - Photometric method (Manganese content between 0.0005 and 1.5 %)
ISO/R	952-1969	Testing of light metal and light metal alloy tubes
ISO/R	953-1969	Drift expanding test on light metal and light metal alloy tubes
ISO/R	954-1969	Simple bend test for light metal and light metal alloy sheet and strip of thickness between 0.2 mm (0.008 in) and 7 mm (0.25 in)
ISO/R	955-1969	Flattering test on aluminium and aluminium alloy tubes
ISO/R	956-1969	Tensile test for light metal and light metal alloy wires

ISO/R 958-1969	Wrapping test of aluminium and aluminium alloy wire
ISO/ 1118-1979	Aluminium and aluminium alloys - Determination of titanium - Spectrophotometric chromotropic acid method
ISO/ 1247-1974	Aluminium pigments for paints
ISO/ 1784-1976	Aluminium alloys - Determination of zinc-EDTA titrimetric method
ISO/ 2063-1973	Metallic castings - Protection of iron and steel against corrosion - Metal spraying of zinc and aluminium
ISO/ 2085-1976	Anodizing of aluminium and its alloys - Check of continuity of thin anodic oxide coatings - Copper sulphate test
ISO/R 2092-1971	Light metals and their alloys - Code of designation
ISO/ 2106-1976	Anodizing of aluminium and its alloys - Determination of man per unit area of anodic oxide coatings - Gravimetric method
ISO/R 2107-1971	Light metals and their alloys - Temper designations
ISO/ 2128-1976	Anodizing of aluminium and its alloys - Determination of thickness of anodic oxide coatings - Nondestructive measurement by split-beam microscope
ISO/ 2135-1976	Anodizing of aluminium and its alloys - Accelerated test of lightfastness of coloured anodic oxide coatings

ISO/TR 2136-1977	Wrought aluminium and aluminium alloys - Rolled products - Mechanical properties
ISO/R 2142-1971	Wrought aluminium and aluminium alloys - Selection of specimens and test pieces
ISO/R 2143-1971	Surface treatment of metals - Anodization of aluminium and its alloys - - Extimation of the loss of absorptive power by colorant drop test with prior acid treatment
ISO/R 2147-1971	Aluminium alloys - Sand cast test pieces - Mechanical properties
ISO/ 2297-1973	Chemical analysis of aluminium and its alloys - Complexometric determination of magnesium
ISO/R 2376-1972	Anodization (anodic oxidation) of aluminium and its alloys - Insulation check by measurement of break-down potential
ISO/R 2378-1972	Aluminium alloy chill castings - Reference test bar
ISO/R 2379-1972	Aluminium alloy sand castings - Reference test bar
ISO/R 2437-1972	Recommended practice for the X-ray inspection of fusion welded butt joints for aluminium and its alloys and magnesium ant its alloys 5 to 50 mm thick
ISO/R 2637-1973	Aluminium and its alloys - Determination of zinc - Atomic absorption method
ISO/R 2767-1973	Surface treatments of metals - Anodic oxidation of aluminium and its alloys

	- Specular reflectance at 45 degrees - Total reflectance - Image clarity
ISO/TR 2778-1977	Wrought aluminium and aluminium alloys - Drawn tubes - Mechanical properties
ISO/TR 2779-1973	Aluminium machining alloys - Chemical composition and mechanical properties of Alloys Al-Cu6 Bi Pb and Al-Cu4 Pb Mg
ISO/R 2931-1975	Anodizing of aluminium and its alloys - Assessment of quality of sealed anodic oxide coatings by measurement of admittance or impedance
ISO/R 2932-1973	Anodizing of aluminium and its alloys - Assessment of sealing quality by measurement of the loss of mass after immersion in acid solution
ISO/R 3116-1974	Wrought magnesium-aluminium-zinc alloys - Mechanical properties
ISO/TR 3134/1-1977	Light metals and their alloys - Terms and definitions - Part I. Materials
ISO/TR 3134/2-1977	Light metals and their alloys - Terms and definitions - Part II. Unwrought products
ISO/TR 3134/3-1977	Light metals and their alloys - Terms and definitions - Part III. Wrought products
ISO/TR 3134/4-1977	Light metals and their alloys - Terms and definitions - Part IV. Castings
ISO/ 3210-1974	Anodizing of aluminium and its alloys - Assessment of sealing quality by measurement of the loss of mass after immersion in phosphoric-chromic acid solution

ISO/	3211-1977	Anodizing of aluminium and its alloys - Assessment of resistance of anodic oxide coatings to tracking by deformation
ISO/	3255-1977	Magnesium and magnesium alloys - Determination of aluminium - Chromazurel S photometric method
ISO/	3256-1977	Aluminium and aluminium alloys - Determination of magnesium - Atomic absorption, spectrophotometric method
ISO/	3335-1977	Extruded solid profiles in aluminium-zinc-magnesium alloy Al 244.5 Mgl (7020) - Chemical composition and mechanical properties
ISO/	3978-1976	Aluminium and aluminium alloys - Determination of chromium - Spectrophotometric method using diphenylcarbazide, after extraction
ISO/	3979-1977	Aluminium and aluminium alloys - Determination of nickel - spectrophotometric method using dimethyl-glyoxime
ISO/	3980-1977	Aluminium and aluminium alloys - Determination of copper - Atomic absorption spectrophotometric method
ISO/	3981-1977	Aluminium and aluminium alloys - Determination of nickel - Atomic absorption spectrophotometric method
ISO/	5191-1980	Wrought aluminium and aluminium alloy products - General conditions for inspection and delivery

ISO/	6581-1980	Anodizing of aluminium and its alloys - Determination of the fastness to ultra-violet light of coloured anodic oxide coatings
ISO/R	2101-1971	Aluminium and aluminium alloys - Shear test for rivet wire and rivets
ISO/R	190-1961	Tensile testing of light metals and their alloys
ISO/R	191-1971	Light metals and their alloys - Brinell hardness test
ISO/R	192-1971	Light metals and their alloys - vickers hardness test

Remark: R = Recommendation
TR = Technical Report

Source: 1981 ISD Catalogue, Geneve

LITERATURE

I. Books and papers

1. United Nations: The competition of steel and aluminium.Vienna, 1954, 162 p. E/ECE/184 (English)
2. Ehrlich, E. and co-workers: Levels, proportions and patterns of economic development (Budapest, Institute of Economic Planning. Manuscript.)
3. United Nations Industrial Development Organization (UNIDO). Workshop on case studies of aluminium smelter construction in developing countries. (Vienna, 27-29 p. 1977. Final Report, ID/WG 250/18. 26. Aug. 1977. 15-16 p.)
4. Spector, S.R.: Short, medium and long-range trends in aluminium supply (demand). Paper presented at the UNIDO Seminar, Budapest, 3-12. May 1978. 11 p.
5. Relle, P., Kramer, M.: A világ bauxit-, timföld- és aluminiumipara (Bauxite, alumina and aluminium operations in the world) Budapest, MINERALIMPEX, 1977. 28 p. (Hungarian)
6. Dr.Domony, A.: Aluminium kézikönyv (Aluminium Handbook) Budapest-Praha-Berlin - Warsawa, Müszaki Kiadó, 1967/ 939 p. (Hungarian)
7. Czellecz, F., Gárdonyi, J., Sidó B.: Erősáramu berendezések szerelése (The installation of heavy power equipment) Budapest, Müszaki Kiadó, 1965. 355 p. (Hungarian)
8. Kardos, Gy.: Müanyagszigetelésü erősáramu vezetékek és kábelek (Plastic-insulated high-power conductors and cables) Budapest, Müszaki Kiadó, 1966. 355 p. (Hungarian)

9. The world metals economy to 1990. Chase Econometric Ass. Inc. (English)

10. Baránszky-Jób, I.: Az aluminiumról (About the aluminium) Budapest, Akadémiai Kiadó, 1973. 223 p. (Hungarian)

11. Kolosy, E., Nagy, P.: Timföldgyártás és aluminiumkohászat (Alumina production and smelting) Budapest, Müszaki Kiadó, 1979. 165 p. (Hungarian)

12. van Horn: Aluminium, I-III. American Society for Metals, Ohio (English)

13. Izmann, R.: Aluminiumöntés (Aluminium casting) Budapest, Nehézipari könyv- és Folyóiratkiadó Vállalat, 1954, 271 p. (Hungarian)

14. Reimer, V.: Nyomásos öntés (Pressure casting) Budapest, Müszaki Kiadó, 1978. 270 p. (Hungarian)

15. Torstad, I.L.: Die Cast Engineering. 1980 /24/ 1, 16-21 p. (English)

16. Barrand, P.M., Gadean, R.M.: L'Aluminium, I-III. Paris, Eysolles, 1964. 939, 944 p. (French)

17. Aluminium-Taschenbuch 13. Neubearb.Aufl. Düsseldorf, Aluminium-Verlag, 1974. 1056 p. (German)

18. Hatch, D.E., Jonstad, I.L.: Aluminium Structural castings in US-automobiles. Aluminium. Düsseldorf, 1978 /54/, 11, 695-697 p. (German)

19. Kecskés, I.: Aluminium anyagok vágása és hajlitása (Cutting and bending of aluminium) Budapest, ALTAK, 1972. 52 p. (Hungarian)

20. Kecskés, I.: Az aluminium anyagok mélyhuzása (Deepdrawing of aluminium) Budapest, ALTAK, 1972. 60 p. (Hungarian)

21. Varga, I.,: Az aluminiumhegesztés technológiája (Welding technology of aluminium) I-II. Budapest, ALTAK, 1971, 1972. 86, 143 p. (Hungarian)

22. Varga, I.,: Az aluminium ragasztása (Bonding of aluminium) Budapest, ALTAK, 1971. 92 p. (Hungarian)

23. Fülöp, S.: Aluminium félgyártmányok helyes megválasztása (Proper selection of aluminium semis) Budapest, ALTAK, 1972. 20 p. (Hungarian)

24. A foundry for the continuous rolling of aluminium strip. Fundicao, 1979. (117) p. 17-24. (Portuguese)

25. World Statistics, UN, New York, 1982. (English)

26. Industrial joint-venture agreements. UNIDO. 1971.

27. Manual for the preparation of industrial feasibility study. United Nations, New York, 1978. 258 p. (English)

28. Industry 2000. New Perspectives, UNIDO, Vienna, 1979. 242 p. (PID/237/ID.CONF.423). (English)

29. Manual of Export Promotion Techniques. UNCTAD/GATT, Geneva.

30. Metalworking Industries in Developing Countries of Africa. United Nations, New York, 1980 (English)

31. A statistical review of the world industrial situation. 1980. UNIDO, Vienna, 1981. (English)

32. World development report, 1980. The World Bank, New York, 1980.

33. Export Marketing Research for Developing Countries UNCTAD/GATT, Geneva.

34. Development of Industrial Export, UN, New-York.

35. Mineral Processing in Developing Countries, UNIDO, Vienna, 1980. 143 p. (ID/253) (English)

36. Information sources on industrial training, UNIDO, Vienna, 1980. 115 p. (English)

37. The development of aluminium sales up to 1990.
(Analysis and forecast of the aluminium) (English)
(Consumption in selected markets and industries)
Working team of PROGNOS AG, Basel (Switzerland)
UNIDO, Vienna, 1980. (English)

II. Periodicals

Aluminium, Düsseldorf (German)
Aluminium Abstracts, New York (English)
Aluminium Currier, London (English)
Alluminio, Milano (Italian)
BKL (Kohászati Lapok), Kohászat, Budapest, (Hungarian)
Chronique d'Aluminium, Bruxelles (French)
Corrosion Science, New York-Oxford (English)
Indian and Eastern Engineer, Bombay (English)
Journal of the Institution of Engineers, Calcutta (English)
Journal of Industrial Economics, Oxford (English)
Journal of Metals, New York (English)
Light Metal Age, San Francisco (English)
Magyar Aluminium, Budapest (Hungarian)
Materials Science and Engineering, Lausanne (French, German)
Metal Bulletin, London (English)
Metal Bulletin Monthly, London (English)
Metal Forming, London (English)
Metals and Materials, London (English)
Revue de l'Aluminium, Paris (French)
Schweizer Aluminium Rundschau, Zurich (German, French)
World Metal Statistics, Birmingham (English)